

SAE

Journal

JANUARY 1958

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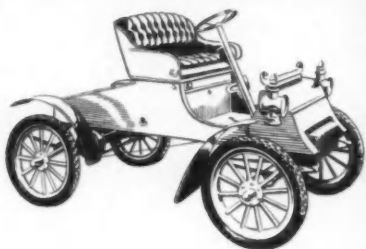
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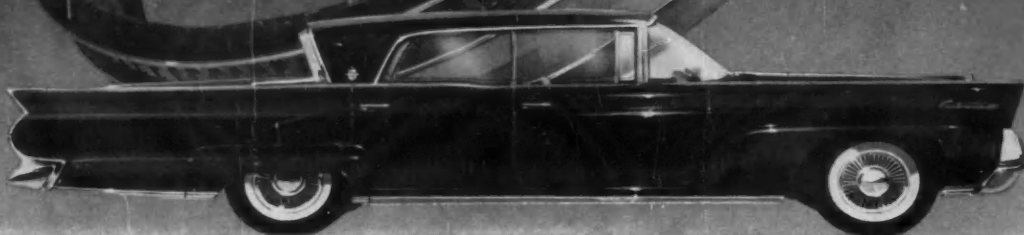


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AIRCRAFT

Role of Complex Wave Excitation in Equipment-Protection Problem, R. S. BRADFORD. Paper No. 196 presented Sept.-Oct. 1957 3 p. Reference made to S-12 Shock and Vibration Committee concerned with design of vibration isolators to protect electronic equipment in aircraft; efforts of subcommittee formed to apply more recent concepts and techniques into study of equipment protection problem; newer complex wave approach as it affects analysis of vibration source, equipment subject to vibration, and isolation systems devised.

Selection of Shock and Vibration Isolators, S. RUBIN. Paper No. 197 presented Sept.-Oct. 1957 13 p. Progress report of Subcommittee in Isolation Systems, responsible for description of isolators, elements of system whose function it is to provide vibration isolation required between source and receiver; objectives are: to specify parameters necessary, to formulate design procedure with emphasis on specification and choice of isolators; and to recommend techniques for measuring isolator properties.

GROUND VEHICLES

Tractor Hydraulics, Good Field, No Hit, G. L. HERSHMAN. Paper No. 189 presented Sept. 1957 15 p. Advantages and disadvantages of present day systems; simple basic units such as blocked return line system for single acting cylinder, blocked pump inlet, and basic open center system; advance stage hydraulic systems such as two versions of open center valve, with series cylinder, or parallel cylinder circuit; closed center valve systems with pressure regulator; central hydraulic and accumulator systems.

Styling and Aerodynamics, V. M. EXNER. Paper No. S17 Sept. 1957 (Detroit Sec) 8 p. How aerodynamic considerations influenced design of current Chrysler production cars and "Dart" experimental car shape evolved from further application of air flow factors; results of wind tunnel tests,

carried out separately at University of Detroit and Turin, Italy; analysis led to aerodynamically styled body of "Dart," built by Ghia Body Co., Turin; fins are essential and integral part of 4-seat sedan minimizing wind wander at normal driving speeds.

Gasoline Injection for Automotive Engines, T. R. THOREN. Paper No. S24 presented Feb. 1957 (San Diego Sec) 15 p. Principles of gasoline injection considered from standpoint of metering accuracy and flexibility, selling price, and capital investment; existing types in United States and Europe of timed or continuous injection systems both of which are in road testing phase; deficiencies of carburetor intake manifold combination; requirements and desirable features.

Trends in Electrical Power Assists for Automated Automobiles, V. H. HARDY. Paper No. S21 presented Sept. 1957 (Detroit Sec) 10 p. Three systems of obtaining assists by means of electricity in conjunction with storage battery and their requirements; use of shunt, compound, and series motors; series motor with shorted turns in armature, developed especially for actuator application on automobiles; four categories of gear reductions in use; applications of present usage and future possibilities listed.

Three Point Hitch Proposed Standards—Farm Equipment Institute Com-

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mittee Report, R. J. MILLER. Paper No. 190 presented Sept. 1957 10 p. Recommendations proposed for inclusion in American Standard on three-link hitch for farm machinery; tables of dimensions for tractor and implement.

Automated Automobiles—Trends in Power Assists, Hydraulic Systems, P.

C. MORTENSON. Paper No. S20 presented Sept. 1957 (Detroit Sec) 18 p. Use of hydraulic energy for actuation of components in addition to brakes, transmissions, and steering by means of central hydraulic system; possible pump arrangements.

Pneumatic Systems and Devices for Automobiles, S. JOHNSON, Jr. Paper No. S18 presented Sept. 1957 (Detroit Sec) 18 p. Features of compressed air suspension system typical of those which will be used on number of 1958 automobiles; suggested use of compressed air for other functions including power braking, power steering, windshield wipers, horns, window lifts, tire inflation systems, engine starting, seat positioners, pneumatic jacks and inflated seat cushions; basic features, components and diagrams of existing systems.

Gas Turbine Competition at Indianapolis, L. WILLIAMS. Paper No. S23 presented Sept. 1957 (Mid-Continent Sec) 9 p. Experimental Boeing gas turbine (Model 502-10F, 300 hp at 5680 rpm, 254 road hp, gear ratio 3.51:1) is compared to average Offenhauser engine running at Indianapolis; fuel consumption; performance; comparison curves of tractive effort vs mph, and velocity, time vs distance; possible arrangement of gas turbine engine using Kurtis 500D chassis.

Some Design and Material Considerations for Three Vital Diesel Engine Components: Exhaust Valves, Cylinder Sleeves, Engine Bearings, A. K. HAN- NUM, J. J. RATAICZAK, J. A. COR- SILLO, F. H. SCHMIDT. Paper No. S22 presented Sept. 1957 (Houston Sec) 17 p. Pt 1: Types of valves used, materials, failures and prevention. Pt. 2: Basic functional requirements of sleeves; characteristics of type "A" and "D" cast iron; sleeve deterioration. Pt 3: Effect of speed on road bearing loads; main bearing loads; lubrication; materials; etc.

NUCLEAR ENERGY

Application of Nuclear Power to Logistic Aircraft Systems, R. W. MID- DLEWOOD, R. B. ORMSBY, Jr. Paper No. 206 presented Sept.-Oct. 1957 16 p. Study of feasibility and method of approach taken by Lockheed Aircraft Corp. in design of nuclear powered aircraft; logistic aircraft requirements; radiation considerations and effects of radiation on various materials influencing shield design; shielding methods, such as separation, unit shielding, and divided shielding of which latter appears to be best compromise; problem of aircraft design.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

ALSO AVAILABLE . . .

. . . 1957 SAE NATIONAL FARM, CONSTRUCTION and INDUSTRIAL MACHINERY PRODUCTION FORUM, presented September 9-10. Secretaries' report of 9 panels on "Factors in Gear & Spline Production," "Quality Control," "Cost Reduction & Control Techniques," "Have You Decided to Automate?," "Supervision Selection, Training & Performance Evaluation," "Welding Methods & Process Control," "Production Planning & Inventory Control," "Heat Treating Techniques," and "Small Gasoline Engine Manufacturing Techniques." Available as SP-320 from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: \$1.50 to members; \$3.00 to non-members.

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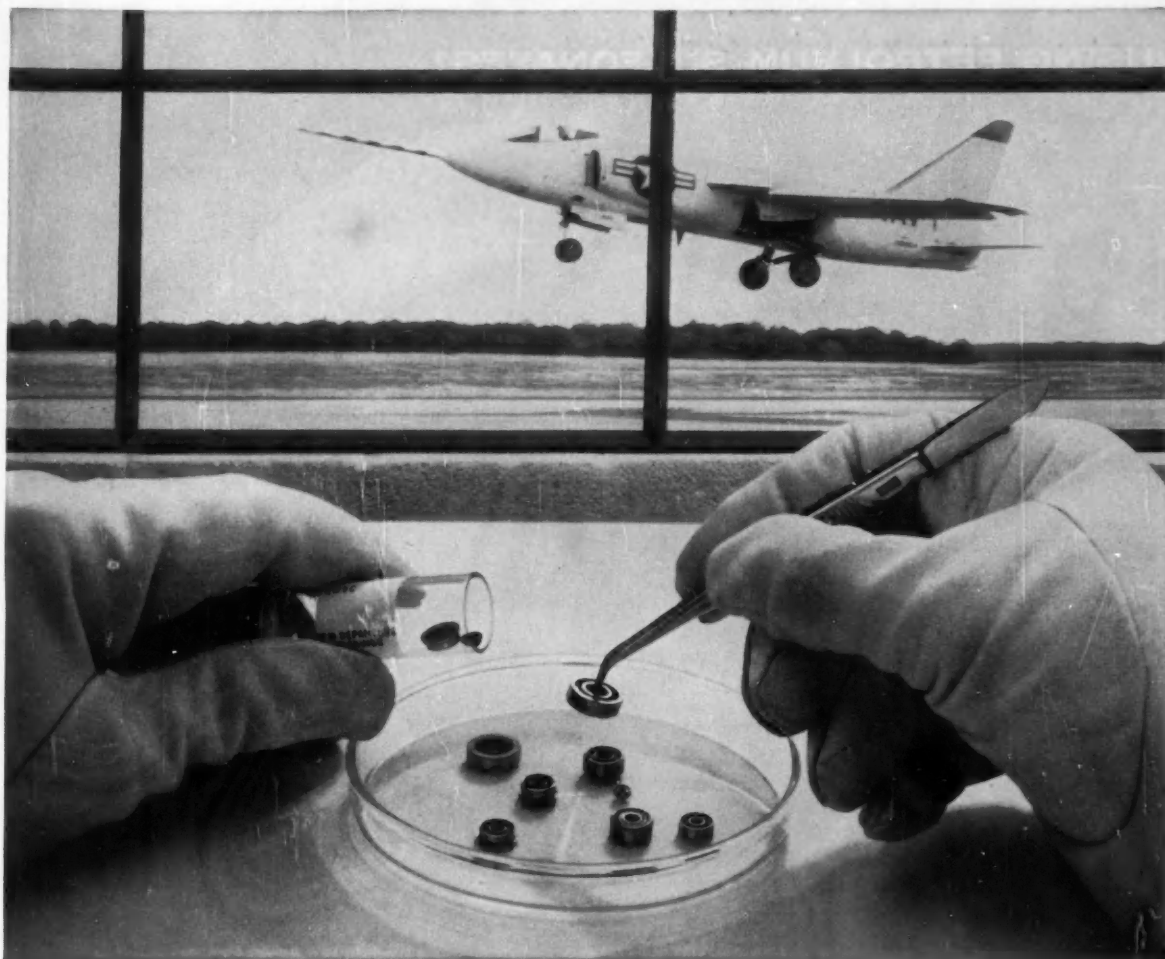
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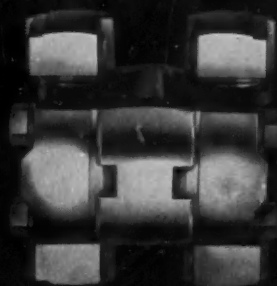


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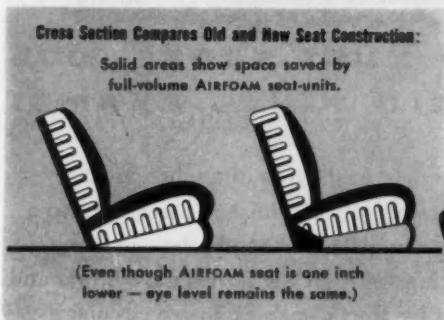
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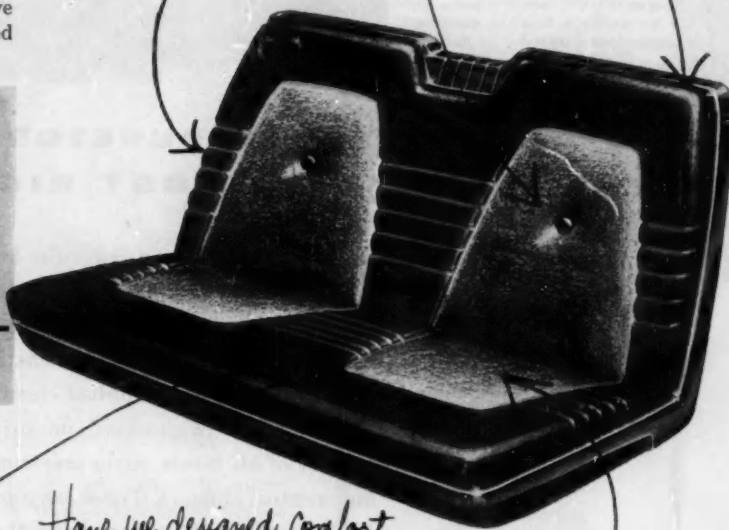
*There aren't any. Practically
any shape can be molded
in AIRFOAM—with
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*Doesn't this piping
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*There isn't any.
Molded AIRFOAM
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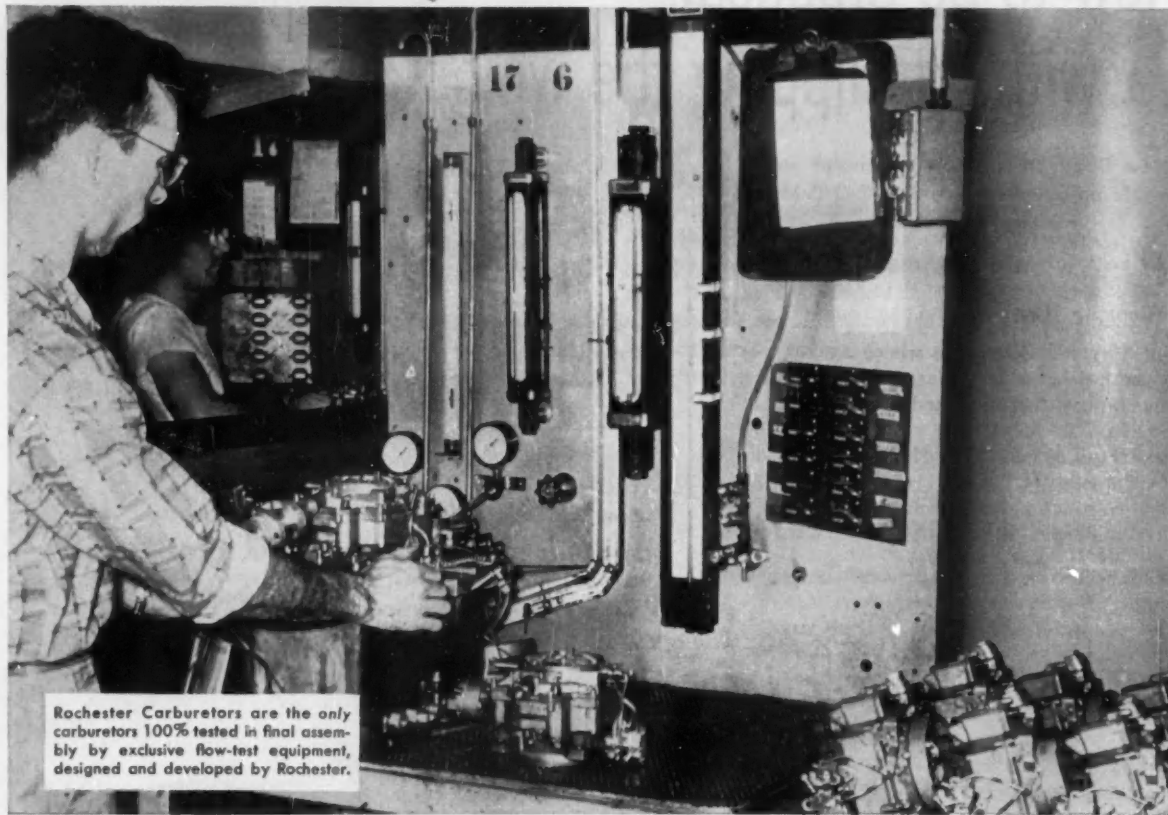


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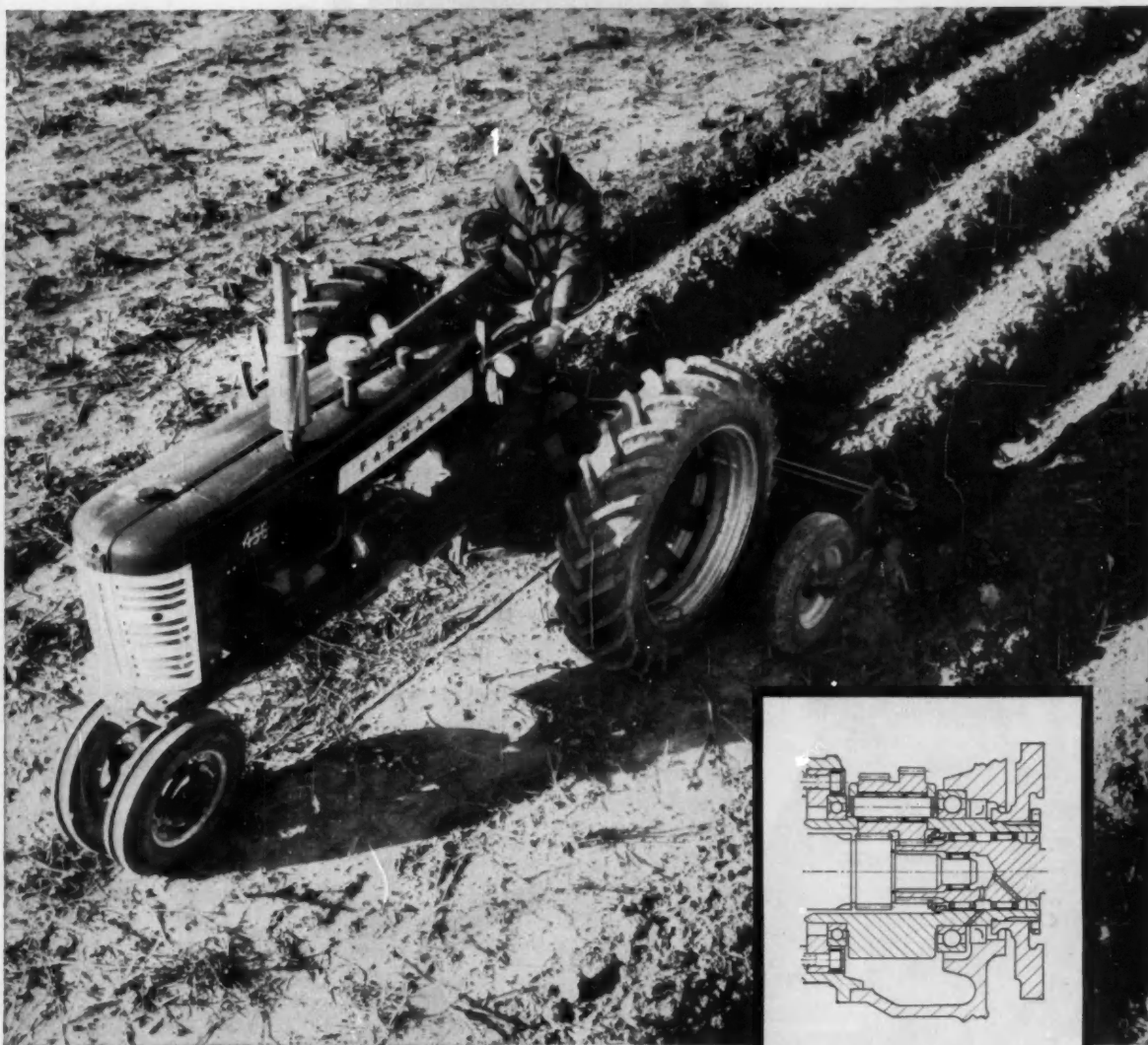


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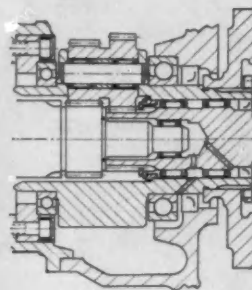
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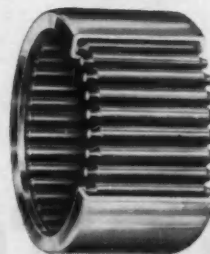
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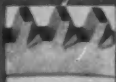
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In the production of alloy steel bars and parts made of alloy steel, stresses are sometimes set up, and these stresses must be relieved before optimum results can be expected. Two general types of stress-relieving are practiced—thermal and mechanical. In this discussion we shall consider only the former.

There are several important reasons for thermal stress-relieving. Among these are the following:

(1) The first and most fundamental purpose is to reduce residual stresses that might prove harmful in actual service. In the production of quenched and tempered alloy steel bars, machine-straightening is necessary. This induces residual stresses in varying degrees. Bars are usually stress-relieved after the straightening operation. When the bars are subjected to later processing that sets up additional stresses, subsequent stress-relieving may be necessary.

(2) A second major purpose of thermal stress-relieving is to improve the dimensional stability of parts requiring close tolerances. For example, in rough-machining, residual stresses are sometimes introduced, and these should be relieved if dimensional stability is to be assured during the finish-machining.

(3) Thermal stress-relieving is also recommended as a means of restoring mechanical properties (especially ductility) after certain types of cold-working. Moreover, it is required by the "safe-welding" grades of alloy steels after a welding operation has been completed.

Alloy bars are commonly stress-relieved in furnaces. Temperatures under the transformation range are employed, and they are usually in the area from 850 deg F to 1200 deg F. The amount of time required in the furnace will vary, being influenced by grade of steel, magnitude of residual stresses caused by prior processing, and mass effect of steel being heated. After the bars have been removed from the furnace, they

are allowed to cool in still air to room temperature.

In the case of quenched and tempered alloy bars, the stress-relieving temperature should be about 100 deg F less than the tempering temperature. Should the stress-relieving temperature exceed the tempering temperature, the mechanical properties will be altered.

Items other than bars (parts, for example) can be wholly or selectively stress-relieved. If the furnace method is used, the entire piece is of course subjected to the heat; selective relieving is impossible. However, if a liquid salt bath or induction heating is used, the piece can be given overall relief or selective relief, whichever is desired.

Detailed information about stress-relieving is available at all times through Bethlehem's technical staff. Feel free to consult with our metallurgists, who will cooperate fully without cost or obligation on your part. And remember that Bethlehem can furnish the entire range of AISI standard alloy steels, as well as special-analysis steels and all carbon grades.

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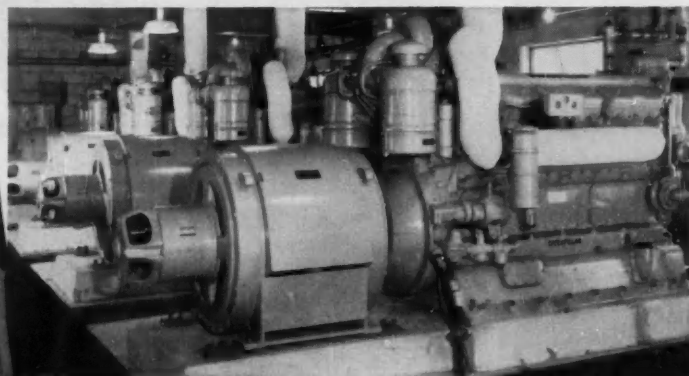
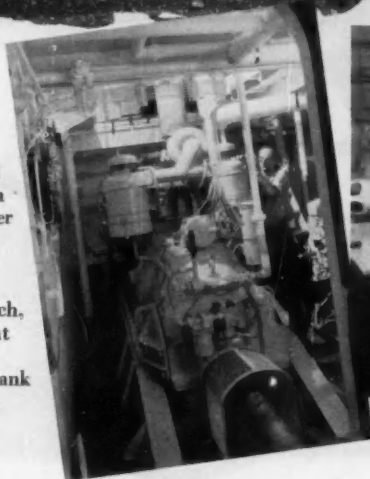
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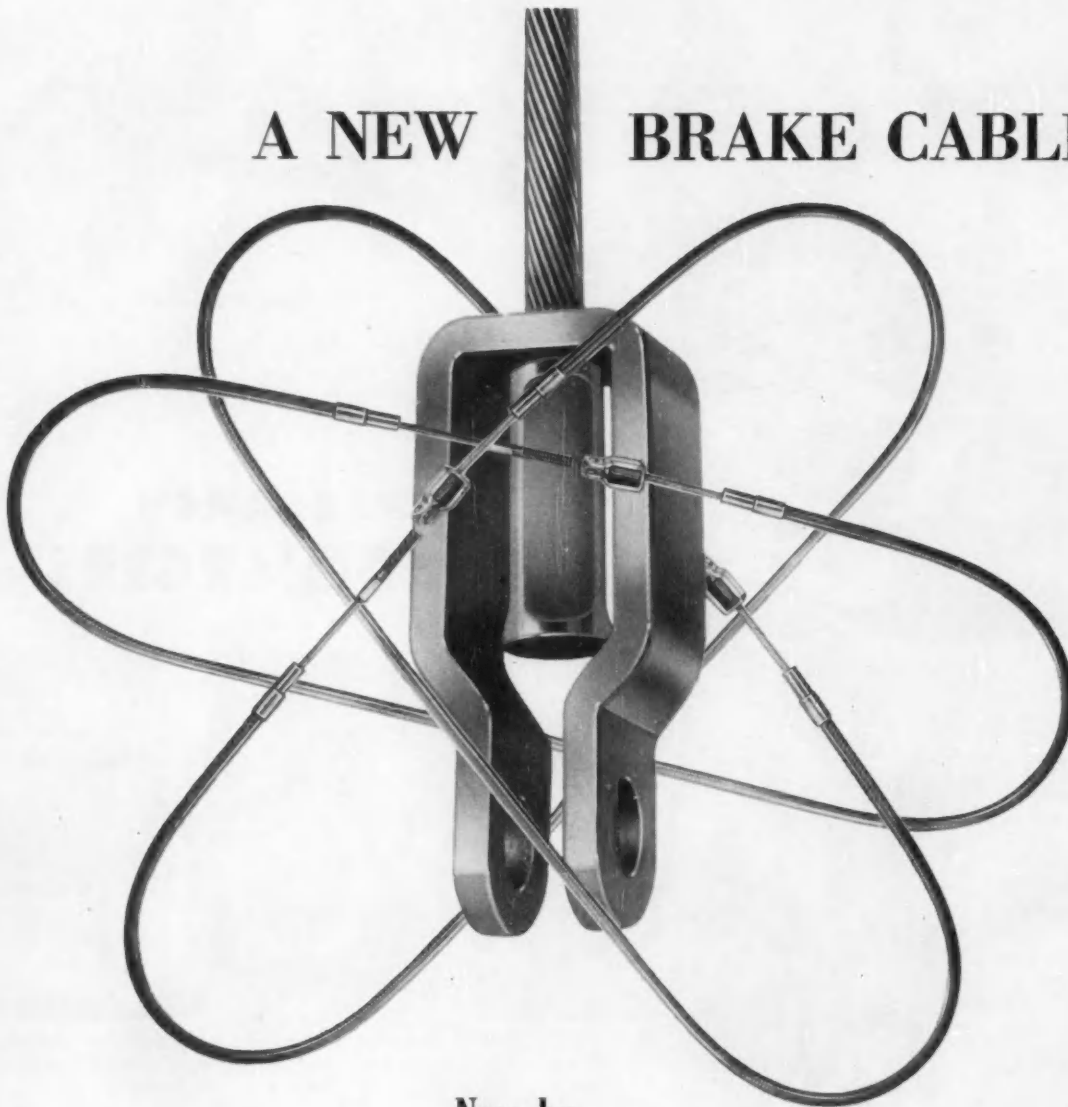
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SAE JOURNAL, JANUARY, 1958

19

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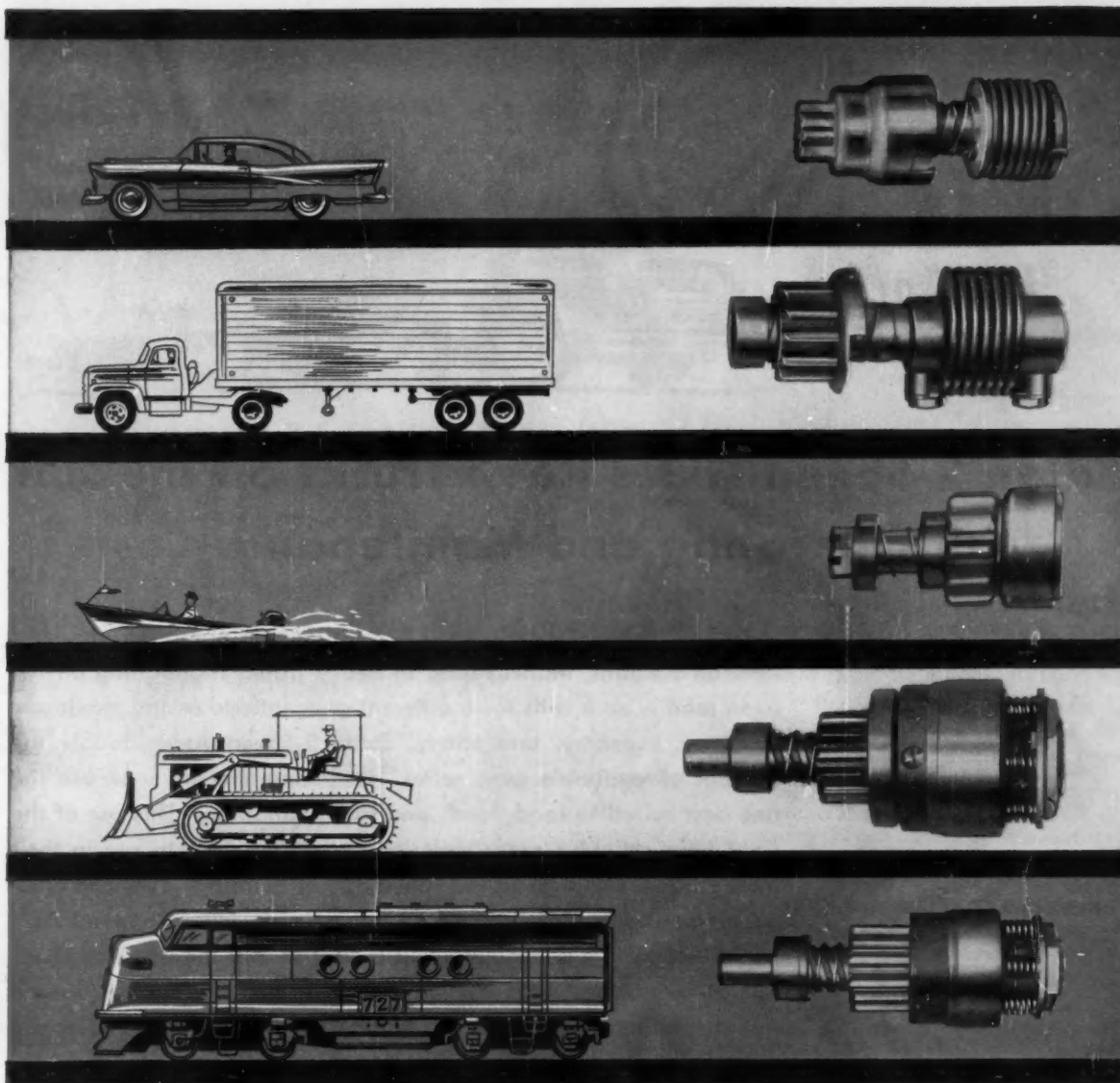
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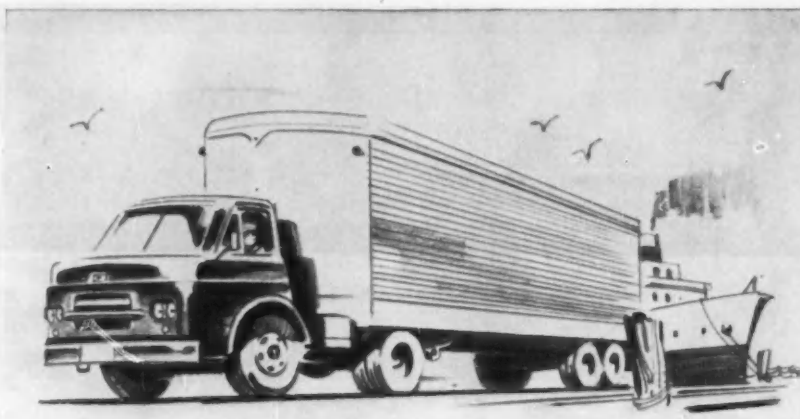
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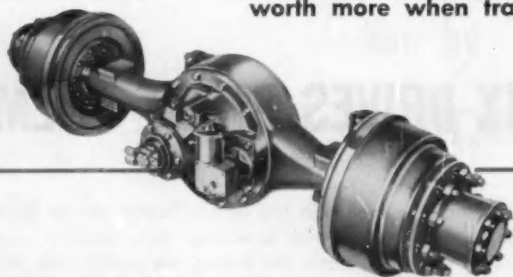
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For The Sake of Argument

"Was He a Good Committee Chairman?"

By Norman G. Shidle

"The best committee chairman is one who manages to bring into play a maximum of initiative and mental activity on the part of every member of his committee . . . provided, of course, that he guides, focuses, and channels the results to a common end."

So philosophized an old hand at SAE committee work the other day. Then, with a reminiscent gleam in his eye, he went on something like this:

How much a chairman should do himself—and how much he should expect to get others to do—depends, obviously, on what he has to work with. It depends on his own particular talents—and on the talents available in his particular group. The chairman's basic responsibility is to get results; his objective, to get the best results possible. The latter come only when the fullest contribution of the entire group has been brought into play.

To be a successful committee chairman calls for a rare combination of practical paradoxes. It requires, for example, a well-stirred mixture of restrained drive, flexible firmness, and relaxed action. It calls for what industrialist Clarence Randall says is needed by the chief officer of a large company . . . "the power of logical analysis, wisdom born of experience, and a talent for communication."

Besides, he has to measure constantly the relation between a desired result and the time required to get it. His is often the deciding opinion on: "Shall we go for the best result possible within a given time; or keep on working for the very best, regardless of time?"

On top of all this, he must be an unusually good self-sorter . . . else he will permit personal or company aims to get mixed up with group or committee aims.

In brief, all that is required to be a completely successful committee chairman is Superman!

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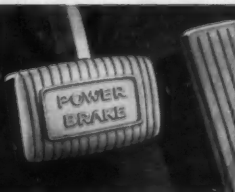
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Planning For Progress

• What It Is • Where It's At

R. J. S. Pigott, Chairman

SAE Planning for Progress Committee

FLEXIBILITY, participation, continuity in the achievement of the Society's chief Constitution-stated objective—the development, collection, and distribution of technical information—that's the goal of the Planning for Progress Committee's proposed revision of the Society's structure.

1956 President George A. Delaney appointed the Planning for Progress Committee at the beginning of his presidential year. SAE Council charged it with finding ways of equipping the Society best to adapt itself to the changing and growing needs of automotive engineers.

In the two years since that time, the Committee has developed a proposed structure for the Society. This proposal—still in its formative stages—envisioned a setup through which SAE members can more readily develop the programs and benefits inherent in SAE activity.

The proposal preserves, the Committee believes, the practices, philosophies, policies and traditions that have contributed to the Society's solid growth for more than half a century. It is designed specifically around the concept of enhancing three key features that have proved important to SAE over the years. They are:

1. **PARTICIPATION**—SAE's strength depends on having as many as possible of its members engaged in Society work . . . contributing to and receiving from this participation. Only from participation and service does a member enjoy greatest satisfaction and get to feel that he's an integral part of SAE.
2. **FLEXIBILITY**—It's highly important that our SAE structure be sufficiently flexible to absorb new or changing technical needs of our members and to produce services that will satisfy these needs.
3. **CONTINUITY**—Our Society's administrative structure should be so designed as to produce a proper blending of knowledgeable men, experienced in handling and leading SAE affairs, with new men who have demonstrated the aptitudes eventually to take up the reins.

Intensive study of a number of plans produced one proposal which gives promise of achieving the

Committee's objectives. The basic structure of this proposal is shown in the attached chart.

Three Boards for Council

Essentially this proposal consists of placing under three Boards, which will report to Council, the main work of the Society. The Boards and their functions are as follows: (*The names of these Boards are tentative at this point.*)

1. Professional Engineering Board

This Board would have responsibility for developing, collecting, and making available technical information of interest and use to SAE members. The Society's National meetings also will come under its aegis.

2. Cooperative Engineering Board

This Board would be exactly the same as the present SAE Technical Board, whose function it is to provide a service to industry and Government on those problems which lend themselves to cooperative technical solution. It is distinguished from the Professional Engineering Board in that it serves industry; the Professional Engineering Board serves the SAE membership.

3. Sections Board

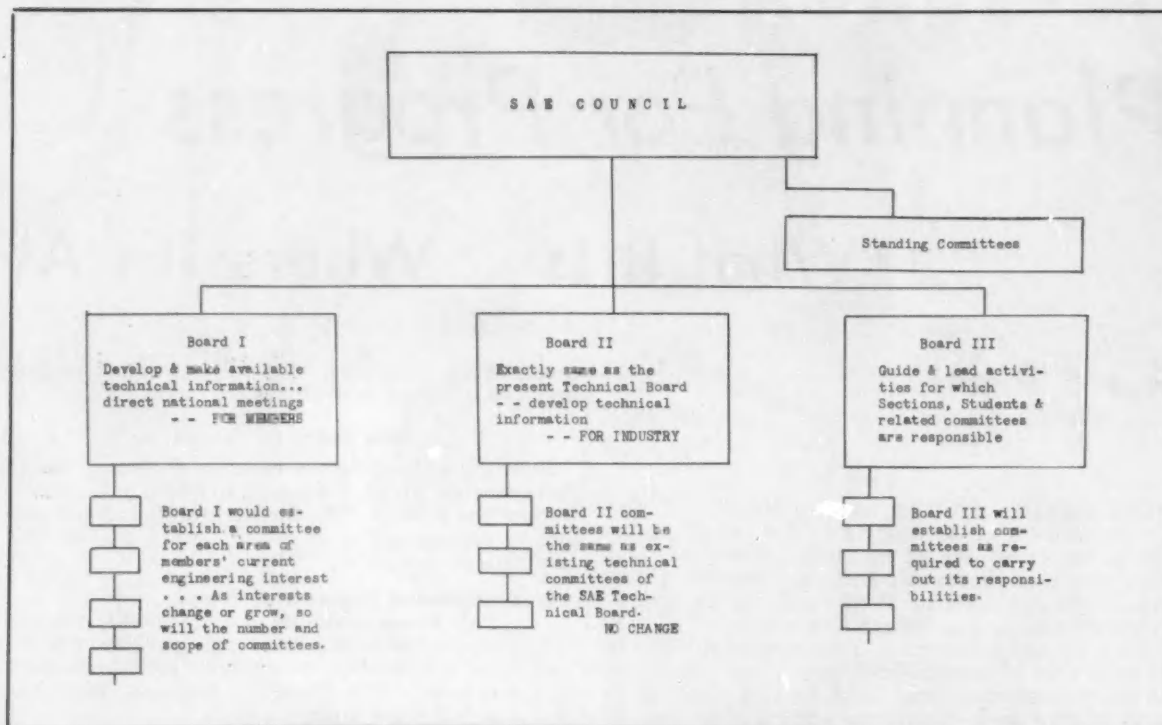
This Board's function would grow out of its job of exercising leadership and guidance of activities currently the responsibility of the SAE Sections Committee and Student Committee.

Its functions might well be:

- a. To channel effectively for Section, Group and Student unit use the various services and facilities of the Society;
- b. To recommend to SAE Council policies and procedures for activities and expenditures under which Sections, Groups and Student units may best carry out the main purposes of the Society;
- c. To effect a continuing liaison between Sections, Groups and Student units and the Cooperative Engineering Board, the Professional Engineering Board, and the various committees of the SAE Council.

Some Thinking Behind Planning for Progress

Inspiration for the Planning for Progress program itself grew out of the apparent inflexibility of the



Society's present structure, particularly in the Professional Activity area. SAE members were becoming interested in, and were beginning to work in many newer fields of automotive engineering not fully encompassed by the 12 Professional Activities. There seemed to be no place in the existing structure, for instance, to serve the technical information needs of SAE members concerned with work on small engines, nuclear energy, guided missiles, computers and other growing areas. As SAE Past President Rosen stated at the inception of the Planning for Progress project "What we need in SAE are rubber pigeonholes rather than cast-iron ones. We need rubber ones to assimilate our rapidly changing technology."

In casting about for these rubber pigeonholes, the Planning for Progress Committee turned its attention to the current Technical Board and the operation of its technical committees.

The Technical Board has the authority to create committees as needs are brought to its attention, and disbands these committees once there no longer is any need for work in that area.

With the Technical Board as a pattern, the Planning for Progress Committee conceived of a Professional Engineering Board which would organize and administer working engineering committees under its leadership. A PEB committee would be established in each area of active automotive engineering interest. Its work would be to develop, collect and make available technical information. . . . As the interests of SAE members changed or grew, so would the number and scope of the PEB committees.

These PEB committees would function in some

respects much like the technical committees of the SAE Technical Board do today. They would concern themselves with engineering problems, developments, and advances in their respective fields. It is planned that they would conduct studies, develop reports and other technical information, to be made available to SAE members through the Society's meetings and publications.

These groups would carry on their work and report periodically to the Professional Engineering Board. They would also submit their reports to the Professional Engineering Board for its approval so that they may be made available to the SAE membership.

Precedents Being Followed

Actually there already is a precedent for such type of operation in the currently operating SAE Nuclear Energy Advisory Committee. This group has contributed regularly information of interest to automotive engineers on nuclear advancements. The Nuclear Energy Advisory Committee has also participated actively in technical sessions at SAE National meetings, having taken the responsibility for furnishing papers and complete programs for these sessions.

The Planning for Progress Committee visualizes the development, organization, and management of National meetings in a way that will not be a radical change from current practices. As is the case with three SAE National meetings today (the SAE Spring National Aeronautic Meeting, Fall National Aeronautic Meeting, and National West Coast Meeting) the responsibility for creating technical programs for these meetings is turned over to the General Chairman located in the vicinity of the site of the meeting. He sets up a Program Committee and re-

ceives paper and program assistance from Activity Committees interested in the technical area covered by the meeting.

Under the proposed Professional Engineering Board, the PEB would appoint a General Chairman for each National meeting. In developing his Program Committee, this General Chairman would draw for its membership from those engineering committees under the Professional Engineering Board which have an immediate interest in the National Meeting subject area.

As visualized by the Planning for Progress Committee, the Society's pattern of National meetings might conceivably change as emphasis and interest within the Professional Engineering Board's engineering committees changed.

As stated before, the Cooperative Engineering Board would be set up pretty much as is the Technical Board today. The detailed operation of the Sections Board has not as yet been delineated.

However, in the case of all three Boards, it is planned that they should consist of 24 members each for a three-year term, with one-third of the membership rotated each year. The Chairman and the Board members would be appointed by the SAE President with Council approval.

In addition to the three Boards that would report directly to Council under the Planning for Progress proposal, there would also be seven standing committees reporting to Council. They are:

- Finance
- Publications
- Membership Grading
- Public Relations
- Constitution
- Membership
- Placement

SAE Council

Another phase of the Planning for Progress Committee's proposal is to provide greater continuity

in the membership of SAE Council. It is proposed that Council shall consist of 22 members—as it does now. These members of Council would be:

- SAE President
- The two immediate Past-Presidents
- The Treasurer
- Eighteen Councilors, each of whom shall be elected for a three-year term, with six new Councilors elected each year.

Procedures for nominating these officers would remain pretty much as they are today. The Annual Nominating Committee would consist of delegates from each of the Sections, as it does currently, except that there would be 12 delegates-at-large instead of the three presently provided for by the Constitution. The 12 delegates-at-large on the Annual Nominating Committee would be elected by the SAE members at one or more Society business meetings.

The Present State of the Proposal

With Council's authorization, the Planning for Progress Committee has already started working with the Constitution Committee to see what changes in the Constitution and By-Laws will be needed to encompass the proposed structure. At the same time, the Planning for Progress Committee has been given the green light by Council to work with other SAE committees to develop practical operating plans for the proposed structure. The aim here is to enlist the help of those members in the Society knowledgeable and experienced in the Society's main operations, such as meetings, publications, sections, membership, student activities, and placement.

When the practical operating guides for the new Boards and committees proposed by the Planning for Progress Committee are detailed to the Committee's satisfaction, it will make its final report to the Council.



DISCUSSION AND INTEGRATION of comments from member groups will be a major agenda item at the January 10 meeting of the PLANNING FOR PROGRESS COMMITTEE (above). Comments result from recent conferences with members of Meetings, Sections, Publications, Finance, and other standing committees at which were discussed the plans outlined in this article. The Committee (left to right): William K. Creson, W. Paul Eddy, G. A. Delaney, Leonard Raymond and R. J. S. Pigott.

Aids for Designing

1. Brittle Lacquers

Based on paper by

E. J. Eckert,

Caterpillar Tractor Co.

BRITTLE lacquer and wire-resistance strain gages have proved to be very helpful tools for obtaining information to use in better design of tractor parts.

Four tractor parts which we have examined extensively in the laboratory and in the field using brittle lacquer and strain gages are:

1. Tractor rear axle.
2. Tractor rear wheel.
3. Track link.
4. Engine rocker arm.

Rear Axles

As part of developing a rear axle for large rubber-tired tractors, the loads on the axle were measured in the field for application in setting up laboratory tests. Strain gages were cemented to the axles to determine the maximum torques and the frequency of loading imposed on them during actual earthmoving cycles under a wide variety of conditions. We wanted to increase the strength of the axle without increasing its size. Therefore, we designed and built a nonresonant fatigue machine with which we could determine the effect of variations in material, heat treatment, geometry of spline, and surface treatment on the strength of the shaft.

This machine is capable of loading the axle up to 90,000 lb-ft twice a second. Most of the shafts were run in unidirectional, torsional loading. Specimens can be run in bending as well as torsion, in

either direction, at any mean stress. Strain gages on a lever arm connected to the shaft were used to measure the loads imposed on the shaft. The signal from these strain gages was also used to shut down the machine automatically, in case the loading or the frequency of loading changed.

The critical load for this axle, as found from the field tests, was 50,000 lb-ft. This torque was applied to the experimental axles; the number of cycles they could withstand before failure was the measure of their fatigue strength.

Some conclusions based on these fatigue tests are:

1. The optimum hardness range is Rockwell C 50-55.
2. Straightening the axles slightly decreased the fatigue life.
3. Stringers of nonmetallic inclusions at the surface definitely weaken these axles.
4. Shotpeening increases their fatigue strength; the gain in strength increasing with the intensity of the peening (within the limits of our test).
5. The spline can be strengthened in fatigue by machining a full radius at its root.

Experience has shown that the strongest shafts as indicated by these laboratory fatigue tests are also the longest lived shafts in the field.

Rear Wheels

Because wheel hubs had failed on test tractors, we put strain gages on hubs at the point of failure to measure the stresses under operating conditions. The stresses were highest when the tractors turned corners at high speeds with full loads.

In the laboratory, a setup consisting of two wheels on a short axle was loaded on one rim with a hydraulic jack until the stresses which had occurred during cornering were duplicated. The use of stresscoat verified that the maximum stresses occurred in exactly the same location as the failures.

After we were satisfied that the laboratory pro-

Better Tractor Parts

2. Strain Gages

cedure gave the same type of loading as actual operation, we used it to evaluate other designs.

The designs which looked best in the laboratory were field tested. Since each wheel revolution can cause one complete stress cycle, a critical stress value was selected which was below the endurance limit of the material used in the hub. The accepted design was the least expensive to manufacture of those that were stressed below the critical value. Wheels of this design have been satisfactory in the field.

Track Links

Similar methods and instrumentation were applied to the track link of a track-type tractor. Usually several links support a tractor, but we know from field testing that one link is often required to resist loads greater than half the weight of the tractor.

Again, the stress conditions can be simulated in the laboratory. A three-shoe section of a track assembly was mounted in a fixture so that the center pair of links could be loaded in a press. A loading arm stresses these links about the same way as a track roller does.

After determining the magnitude and type of loading imposed on the track link during field operations, we applied equivalent loads statically in the laboratory at intervals along the track link surface to determine the stress pattern at various locations as the roller moves along the rail. The worn condition of links was simulated by machining off the surface which contacts the roller. In the development of link geometry other portions of the link were built up or machined away to provide progressive changes in section. After each change, a stress distribution was obtained by the use of stresscoat and strain gages.

After an improved geometry was developed for the track link, several material factors such as case depth and hardness were evaluated by fatigue test-

ing. The final design was tested by installing tracks with similar links on a weighted tractor and operating it over rugged, rocky terrain.

Engine Rocker Arms

Stress analysis procedures in the laboratory can be a valuable aid in reducing production costs. Reducing the costs can be accomplished in several ways, such as removing excess material, using a lower cost material, or changing the manufacturing process. Our investigation of rocker arms is an example. Forged steel, pearlitic malleable iron, and cast aluminum were used to make rocker arms of appropriate design.

By applying a static load equal to the maximum dynamic load that can be imposed on the rocker arm in the engine, it was possible to determine the maximum operating stresses in each of the three types.

Stresscoat was used to determine the position and direction of the maximum and minimum principal strains. Strain gages were mounted in these positions to measure the maximum stresses. Both the pearlitic malleable iron and the cast aluminum rocker arms had lower stresses for the given load.

The stress analysis did not complete the project. Wear in the bore is another consideration. Leaded bronze bushings are used in our production steel rocker arms. We think bushings may not be necessary in aluminum or pearlitic malleable iron arms; if this is true, a cost reduction is possible. We are going to determine the wear rates of the different arms by endurance runs in engines. These wear rates and a cost analysis will determine which is suitable and most economical for production.

To Order Paper No. 186 . . .

... on which this article is based, turn to page 5.

CONVERTIPLANES

Helicopters lift better; direct-lift jets go faster. But convertiplanes occupy much of VTOL spectrum. In this article, a Bell engineer tells why.

Based on paper by

R. L. Lichten,

Bell Helicopter Corp.

CONVERTIPLANE—A type of aircraft that uses one or more rotating airfoil systems acting on unheated atmospheric air to provide lift for vertical and low-speed flight . . . and to provide forward thrust for high-speed flight with the lift load transferred to a monoplane wing.

The rotating airfoil system, which may be a rotor-propeller, a conventional propeller, or a ducted propeller, has its axis substantially vertical for low-speed flight . . . and **converts** to high-speed flight configuration by having its axis rotated forward to a generally horizontal attitude.

ANALYSIS of capabilities of various VTOL aircraft types shows the helicopter excelling in lifting ability, the direct-lift jet excelling in speed . . . and convertiplanes occupying a broad part of the spectrum in between.

The position occupied in the VTOL spectrum by the various types of convertiplanes is shown in Fig. 1 for turbine-powered transport-size machines.

The substantial advantage in static lifting effi-

ciency of the conventional helicopter with slightly loaded rotor as compared to other types is evident. This is due to a relatively low rate of energy dissipation in the slipstream. The jump in speed capability from the helicopter to the convertiplane is due to elimination of retreating blade stall and advancing blade compressibility losses. Neither of these is present in the convertiplane high-speed configuration.

The further jump in speed from the convertiplane to the direct-lift jet airplane is due to the large increase in specific thrust obtained when heat is added to the propulsive fluid by burning fuel in it (as in the turbojet engine with or without an afterburner).

In all cases, increasing speed capability implies a correspondingly higher level of aerodynamic cleanliness.

Installed Power Requirement

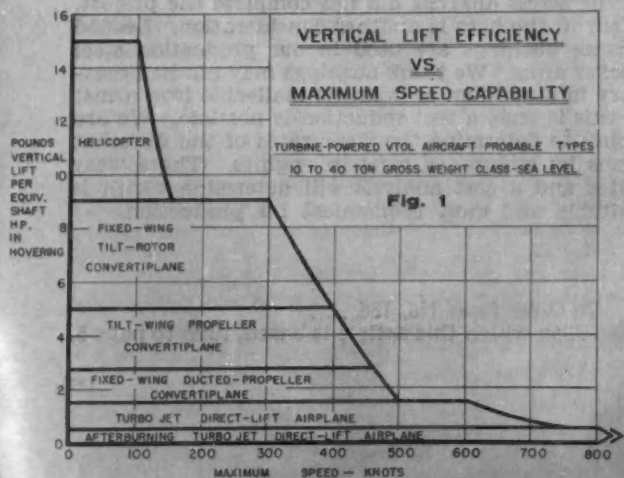
Shown in Fig. 2 is the installed power requirement at sea level for a typical propeller-transport convertiplane to meet a design hovering condition of 5000 ft and 95 F. Shown also is the rate of fuel consumption in hovering on a standard day.

In developing these data, conventional turbine-engine power characteristics without liquid injection for temperature compensation are assumed. The resulting powers are about 50% higher than would be required solely for hovering at sea level on a standard day. Experience with turbine-powered helicopters has shown that such a level of excess power is desirable from the general safety and operational performance standpoint, irrespective of the particular hovering design requirement.

The fuel consumption data indicate that installed power and fuel requirements for the three lower disc loadings are probably within reason. But they indicate, too, that the power requirement is so high at the highest disc loading that the achievement of a practical aircraft having its characteristics is extremely unlikely. Moreover, the applicability of the three types having lower disc loadings to certain missions would depend on the required length of hovering time, in view of the wide variation in hovering fuel rate shown.

Downwash Velocities

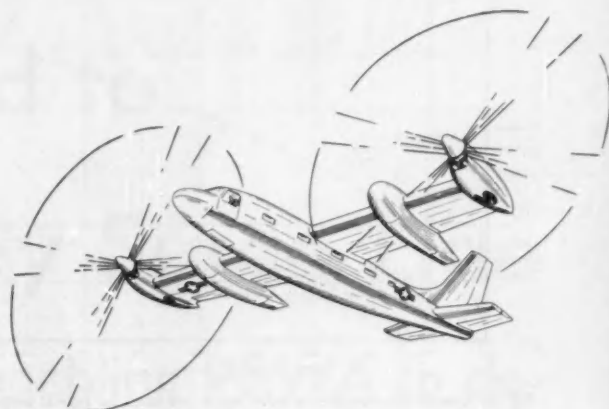
Downwash velocities in hovering at sea level are shown in Fig. 3. Here again, operational require-



COMPARISONS DETAILED in this article result from a simplified analysis of the typical transport convertiplane shown at the right. Its gross weight is 25,000 lb; its rotor propellers 40 ft in diameter; and its powerplants are mounted at the wing tips.

Analysis also was performed for three other propulsion units of smaller diameter.

The design parameters of the four propulsion units were based on disc loadings of 10, 40, 80, and 160 psf, plus the requirement that the propellers be aerodynamically capable of supplying sufficient static thrust to permit hovering at 5000-ft altitude on a 95 F day. Tip speeds and number of blades were selected arbitrarily as considered appropriate for each design.



Among the conclusions drawn are these:

- As disc loading increases, a marked increase occurs in installed power requirement, in hovering fuel rate, and in downwash velocity.
- Cruising range is higher at low disc loadings.
- For fixed-wing convertiplanes, wing flaps provide appreciable reductions in hovering wing download . . . as well as advantages in conversion at altitude and in overload running take-offs.
- Convertiplanes of both the fixed- and tilt-wing type should exhibit excellent short take-off performance at overload.

Design Disc Loading (lbs/sq.ft)	10	40	80	160
Diameter (ft)	40.0	20.0	14.1	10.0
Rotational Tip Speed (ft/sec)	750-900	800-600	850	900
No. of Blades	3	4	6	8
Blade Chord (ft)	1.56	2.06	1.72	1.63
Rotation	Single	Single	Dual	Dual
Solidity	.075	.263	.465	.830

ments would determine how high a disc loading could be tolerated from the standpoint of kinetic energy in the hovering downwash. It is unlikely that ground personnel could continue to function in downwash velocities much above 75 mph.

Forward Flight Analysis

The variations in maximum speed for an altitude of 15,000 ft (shown in Fig. 4) are almost entirely due to the differences in the installed power required by the several designs. This is borne out by the dashed curve—which demonstrates that almost the same maximum speed would be attained by all four designs if each had the same installed power. (The drop in efficiency indicated by the speed decrease for the 160 psf disc loading case occurs because its propellers become somewhat overloaded for the reduced power assumed for the dash curve.)

Cruise Performance

Cruise performance (calculated at 15,000 ft with 10,000 lb of fuel assumed available) is fairly uniform

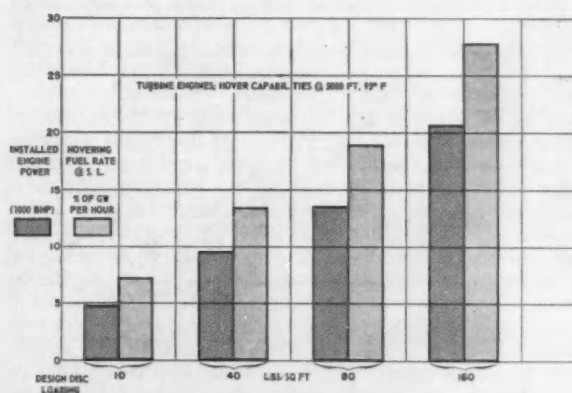


Fig. 2—Installed power requirement at sea level for typical propeller-transport convertiplane to meet a design hovering condition of 5000 ft and 95 F.

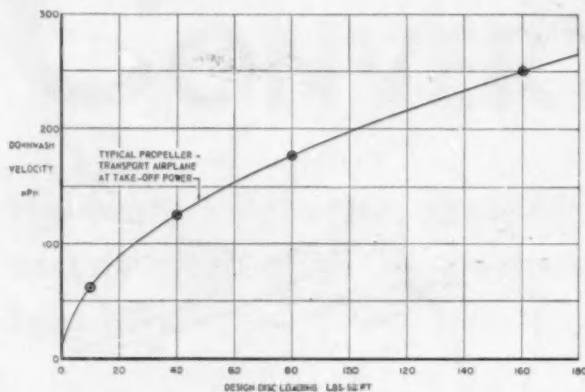


Fig. 3—Downwash velocities in hovering at sea level for typical propeller convertiplane.

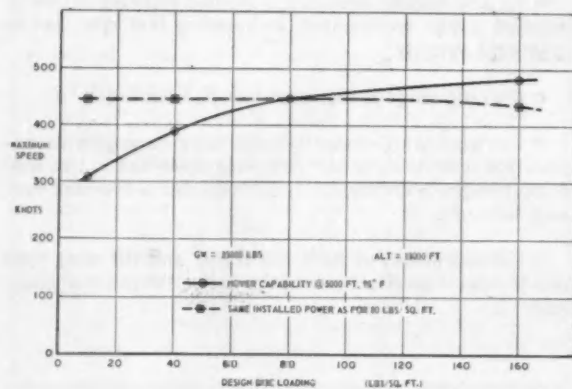


Fig. 4—Variations in maximum speed for an altitude of 15,000 ft are almost entirely due to the differences in the installed power required by the several designs.

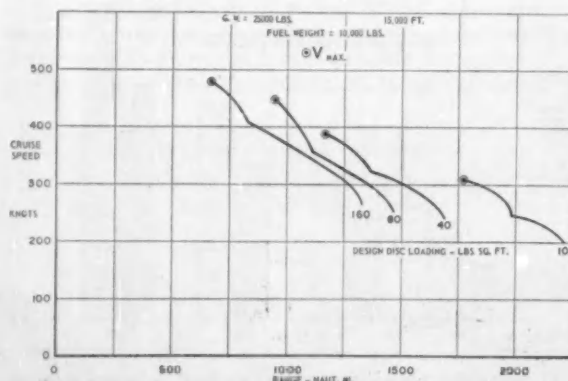


Fig. 5—Cruise performance is fairly uniform among the four designs of convertiplane studied.

among the four types (Fig. 5). If a very high cruise speed is desired, the higher disc loadings must be used . . . or at least the high installed power levels corresponding to those assumed for the high disc loading designs must be provided.

The analysis shows, also, that large-diameter, slow-turning propellers can be at least as efficient in cruise at medium speeds as smaller propellers of greater solidity such as proposed for many VTOL designs.

An appreciable part of the differences that show up in the range comparison, as well as the break in each curve (in Fig. 5) is due to the assumed variation of specific fuel consumption with percentage of maximum power output used in cruise.

The net result is that for designs having a very high installed engine power, maximum range capability is reduced by the necessity of operating—for economical cruise—at greatly reduced total power output, where some penalty in specific fuel consumption must be paid.

Fixed- and Tilt-Wing Characteristics

Other factors being equal, a wing fixed to the fuselage structure of a convertiplane is preferable to one designed to tilt through 90 deg. (Reason for the tilting wing is to avoid loss in lift which occurs when large wing areas are exposed to the downwash from the lifting propellers in hovering and low-speed flight.)

The pilot's ability to vary the proportion of lift provided by the wing and rotor-propellers in low-speed flight is an interesting characteristic of the fixed-wing convertiplane. Appreciable reduction in the power required with forward conversion as the wings begin to carry a portion of the lift load is indicated by flight tests. This results partly from the unloading of the rotor-propellers and partly from reduced parasite drag with improved fuselage attitude.

A fixed-wing disadvantage is that as disc loading is increased wing-loading tends to become excessive. Keeping wing loading in the downwash to a minimum results in wing loadings of about eight times the disc loadings for typical proportions. This can lead to wing stall when the rotors are completely unloaded at conversion airspeeds and at altitude.

A disadvantage with tilting-wing convertiplanes is that flow separation may result when power is reduced either for deceleration or descent. This condition is more likely to occur with moderate than with high disc loadings.

Because of their extremely high available static thrust, all convertiplanes may be used to advantage as STOL aircraft under overload conditions.

For running take-off, the tilting-wing type is converted until the optimum angle of attack is obtained, which may be of the order of 20-30 deg. With a fixed-wing type with low disc loadings, a ground clearance limit usually prevents complete 90-deg conversion with take-offs, but an angle of 40-50 deg is feasible for most designs.

To Order Paper No. 221 . . .

. . . on which this article is based, turn to page 5.

Computer Used to Survey Surge Line

... yields results enabling P&WA to design turbine engine compressors which are stable over the required operating range.

Based on paper by

D. W. Petersen

Pratt & Whitney Aircraft

THE digital computer enabled Pratt & Whitney Aircraft to devise a surprisingly simple means of designing and predicting the surge characteristics of a multistage compressor.

This knowledge of compressor performance—which is so important to the design of gas turbine powerplants—came from a survey of the surge line shape of 500 compressor configurations. Engineers first assembled data from hundreds of single stages, plain cascades, annular cascades, multistage rigs, and a few complete compressors. The data covered the complete range of reasonable compressor stages. From these data and aerodynamic principles, investigators were able to formulate mathematical expressions for the highly complex inter-relationships of the many variables affecting compressor performance. Then they fed the formulas and the combinations of variables into a computer. The results provided the basis for the design theory regarding surge.

This survey was carried out about five years ago, on a card-programmed calculator available then. Equipment more advanced than the CPC is available today, of course. But the survey is still a good example of the uses to which digital computers can be put.

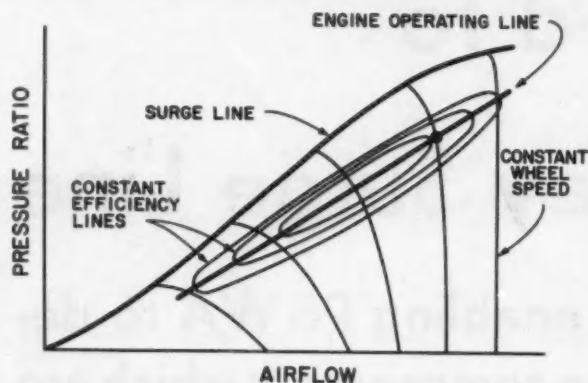
First and major portion of the surge line survey consisted of correlating the results and data from the hundreds of single-stage tests that had been completed up to that time. This correlation was augmented by data on theoretical relationships derived from the basic laws of fluid mechanics and thermodynamics.

In the second portion of the survey, the compressor design mapping was programmed on the CPC machines. This consisted of a flow continuity calculation wherein the maximum permissible stage loadings were determined as a function of the inlet conditions for each stage. Although a wide variety of stages might be designed for a specific job, the mapping calculation assumed that other variables, such as airfoil shape, had been optimized. Thus, the optimum stage was a function of only the stage inlet conditions. Each stage was required to generate the maximum possible pressure ratio in order to minimize the number of stages and the size and weight of the engine. The mapping calculation thus determined the number of stages in each compressor.

The second phase of the study also yielded for every stage of every compressor the coefficients defining the peak pressure, or stall point, and the coefficients of the equations describing their performance characteristics.

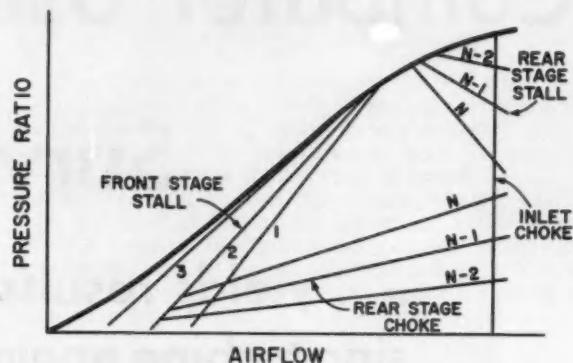
The third phase consisted of adding together the individual stage performance characteristics to determine the pressure ratio versus flow for each speed parameter. This performance calculation began with the choice of a flow and speed which were entered into the first-stage deck as input information. The machine then determined whether the stage was stalled or unstalled. This governed the choice of the proper polynomials to calculate the pressure ratio and the temperature ratio. Stage-pressure rise and temperature rise were calculated from these ratios, and this led to a knowledge of the inlet conditions for the succeeding stage. Calculation of the corrected inlet flow and speed to the second stage completed the calculation loop for a stage, and this loop was repeated for the total number of compressor stages. The machine then summed up the overall pressure ratio and efficiency of the compressor for this performance point, permitting us to plot efficiency contours on the performance map. The

TYPICAL COMPRESSOR PERFORMANCE



ON COMPRESSOR PERFORMANCE MAP, surge line represents boundary between stable and unstable operation. Engine operating line is the locus of points at which turbine output power matches power requirements of the compressor.

STALL AND CHOKE LIMITATIONS



REGION OF EFFICIENT OPERATION is bounded on four sides: Inlet choke limits airflow. Rear-stage choke spoils efficiency at low pressure ratios. Inlet-stage stall limits pressure ratio at low rpm's. Rear-stage stall limits high pressure operation at overspeed.

surge line was defined by the peak pressure ratio point for each speed parameter.

The design phase of this survey required only 10 min per compressor on the card-programmed electronic calculator. The remaining performance evaluation occupied the machine for an average of about 2 hr per compressor.

The surge line survey provided a powerful new technique, but one with still a few major deficiencies. One of these was the failure to account for stage-interaction effects in the multistage compressor. Another was the assumption that the choice of flow pattern, design stall limit, design Mach number limit, degree of reaction, and type of airfoil section would not appreciably affect the results of the survey. These latter variables were not explicitly included because in an engine stage design they are part of the design philosophy. The required peak efficiency sets the Mach number and stall limits; and the required flow per frontal area sets the flow pattern and degree of reaction.

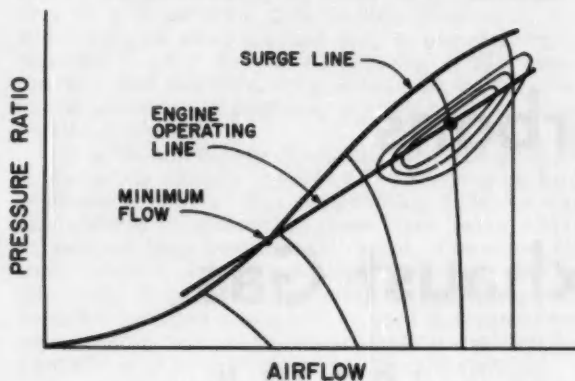
Although these few result-qualifying assumptions were made, a far greater number of simplifying assumptions would have been necessary if the survey had been attempted without the high-speed computers. The same condition obtains for the majority of the calculations made with the machines. Their great relative speed makes it practical to do a far more nearly complete analysis than might otherwise be attempted—in terms of eliminating simplifying assumptions, including less significant terms in equations, and sampling more values of each variable than would otherwise be practicable.

Comparison of the results of this study with those of an earlier hand-calculation project wherein an

attempt was made to evaluate overall pressure ratio effects on surge line shape, is illuminating. In the earlier instance, two and a half man-years were devoted to a hand calculation that yielded questionable results on only three compressor configurations and attempted to evaluate only one prime variable. The surge line survey on CPC machines represented an investment of about 5 man-years and about 1200 hr of machine time. This, admittedly, represented a substantially greater expenditure of time and money. But the results more than justified the expense. In a qualitative sense, there was an indication of the effects of many compressor design variables which otherwise could have been obtained only by extensive testing of a wide variety of multistage compressors. It should also be recognized that the major portion of the engineering time devoted to the survey was spent in correlating the test results from our research programs, rather than in performing routine calculations.

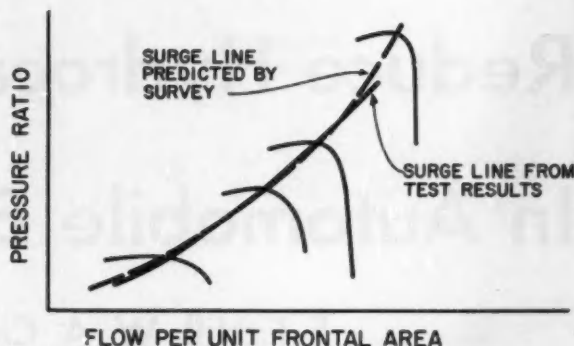
The real proof of the success of the surge line survey lay in the comparison of two computed compressor performance maps with the evidence of actual tested performance. Two of the 500 compressors included in the survey were actual compressors that had seen many hours of test stand operation, compressors whose actual performance characteristics were well documented. The last chart with this article illustrates the tested and calculated performance curves for one of these compressors. The minor differences between these curves were readily explained by known assumptions and simplifications employed in the survey calculations. Thus, the use of electronic digital computers made possible the

POOR LOW SPEED STALL MARGIN



IF SURGE LINE INTERSECTS OPERATING LINE, engine must be turned at a high speed and airflow before it is capable of stable, self-supporting operation. In other designs, margin may be adequate at low speeds but not at high.

SURGE LINE COMPARISON TEST vs. PREDICTED



SURGE LINE PREDICTED on basis of technique developed from survey corresponds closely to that determined by test on this actual compressor. Minor differences are due to assumptions and simplifications made in the calculations.

highly successful conclusion of a project which formerly was virtually impossible.

The knowledge gained from the surge line survey was a major advance in compressor design theory—and the compressor is the major component of the turbine engine from the standpoints of complexity, cost, and difficulty of development.

The surge-line survey is only one of the scores of uses to which the company has put electronic computers. These machines have, in both early and refined versions, rapidly become an integral part of

the engine design and development system. Today, almost all repetitive calculations in the design, reduction of test results, correlation of test results, and development of turbine engines are programmed for and performed on the digital computing machines. The computing laboratory works around the clock and more than justifies the cost of its equipment.

To Order Paper No. 191 ...

... on which this article is based, turn to page 5.

Computers Are Getting Faster and Faster

■ As an indication of the progress being made in computer processing time, the following table gives the time required to add the 218,418 numbers in the Indianapolis telephone directory:

Year	Time to Add
1948	15 min
1952	12 sec
1954	4 sec
1957	2 sec
1960 (projected)	.03 sec

—From a paper by J. S. Fouch presented before SAE Indiana Section.

Oxidation Catalysts

Reduce Hydrocarbons

In Automobile Exhaust Gas

Based on paper by **E. F. Hill, W. A. Cannon, and C. E. Welling**, Ford Motor Co.

A VANADIUM oxide catalyst has been demonstrated to be reasonably tolerant of lead solids in exhaust gas, with effectiveness of more than 80% in the first 100 hr of testing. This catalyst shows overall more than a 50% hydrocarbon conversion in 175 hr of testing with 3 ml per gal of TEL in the fuel.

An operating temperature range of 550 F to 900 F, required to attain and maintain this effectiveness, imposes a design limitation, however, in that any useful device will have to be located near the engine to permit rapid warmup.

This particular catalyst tends to reduce the heat dissipation problem because it oxidizes a major portion of the hydrocarbons to CO and does not oxidize the CO already present. Due to this characteristic, the opinion is expressed that a container fabricated from mild steel would have a satisfactory life with this catalyst.

A recent single-cylinder engine test using leaded and unleaded fuels showed the following results as regards the efficiency and life of various catalysts.

Two metallic catalysts were tested—platinum and nickel.

Fig. 1 shows that platinum is a remarkably effective

catalytic material with unleaded gasoline and that 100% hydrocarbon conversion was obtained for the duration of the test. On the other hand, nickel never attained an efficiency of over 50% and gradually declined in activity.

Three single metal oxides were evaluated—copper oxide, iron oxide, and vanadium oxide.

Fig. 2 shows that iron oxide has a low initial efficiency and rapidly declines in effectiveness while copper oxide gives a high conversion, but only for a short time. Vanadium oxide appeared to increase in activity after a short time and thereafter became stabilized at a conversion level of about 75–80%.

As a group, the mixed oxides show considerable promise (Fig. 3). Although hopcalite fluctuates in effectiveness, it looked very promising in this test. The abrupt change at 42 hr was caused by a decision to raise the catalyst temperature from 445 F to 625 F. The test on copper chromite was terminated at 84 hr due to overheating. And the silver oxide-barium peroxide mixture, although highly effective for a short time, failed in about 15 hr.

The results with platinum, hopcalite, copper chromite, and vanadium pentoxide were sufficiently en-

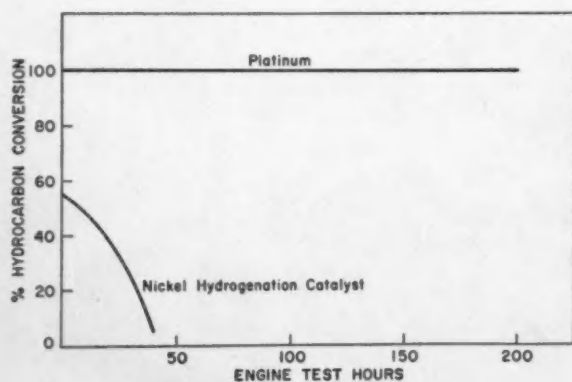


Fig. 1—Performance of metallic catalysts on unleaded fuels.

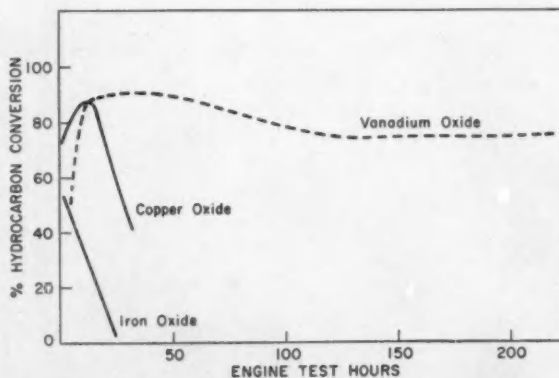


Fig. 2—Performance of metal oxide catalysts on unleaded fuel.

couraging to justify studies with the same fuel containing 3 ml per gal of TEL as motor mix.

The results of the engine test on platinum with and without lead were rather dramatic.

Fig. 4 shows that lead affects platinum in two distinctly different ways: a) there is an immediate drop in activity from 100% to 90% conversion, followed by b) a more gradual drop to complete ineffectiveness after 100 hr of running. This would indicate that two different mechanisms are involved in the poisoning of platinum catalysts by TEL combustion products.

Hopcalite and copper chromite both show promise as materials initially resistant to poisoning by lead as shown in Fig. 5. But considerable difficulty was encountered in preventing them from losing activity because they became overheated. Consequently their relative resistance to lead poisoning may be obscured. Hopcalite starts oxidizing exhaust gas at room temperature and might be used in conjunction with another catalyst to reduce the time required for a converter to become effective on a cold start-up.

Fig. 6 shows that the vanadium oxide is reasonably tolerant of lead salts in exhaust gas up to 125 hr of operation. After this its rate of decline in activity is slow compared to other materials tested. Vanadia is in good supply at a cost which should allow an exhaust device to look more economically attractive than heretofore.

The vanadia catalyst shows over 50% hydrocarbon conversion for 175 hr with 3 ml per gal of TEL in the fuel. It seems likely that a longer catalyst life would have been obtained with a fuel having a lower lead content.

The present vanadia catalyst requires an operating temperature range of 550 F to 900 F to attain and maintain the reported effectiveness. This imposes an important design limitation on the catalytic device in that space will have to be found for it near the engine to allow for the early attainment of operating temperature. A bypass may be necessary to prevent overheating when abnormal operating conditions produce unusually high hydrocarbon concentrations in the exhaust gas.

To Order Paper No. 174...

... on which this article is based, turn to page 5.

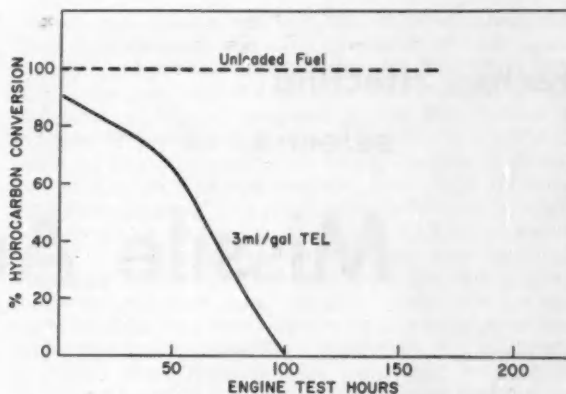


Fig. 4—Effect of lead on a platinum catalyst.

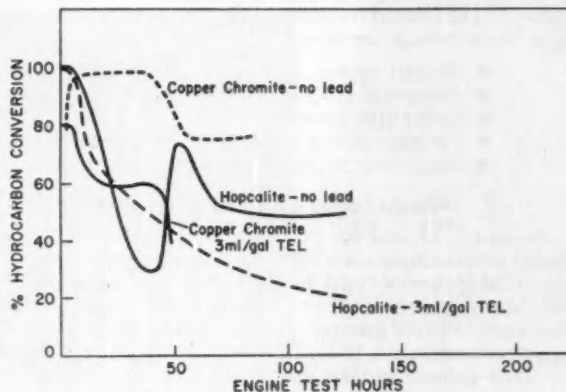


Fig. 5—Effect of lead on hopcalite and copper chromite.

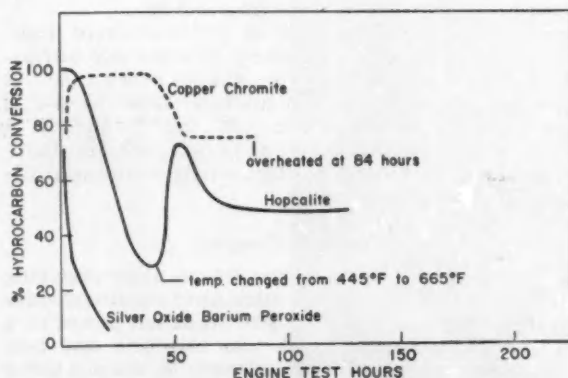


Fig. 3—Performance of mixed oxide catalysts on unleaded fuel.

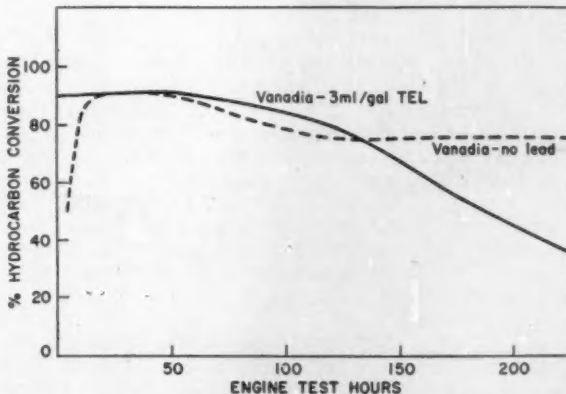


Fig. 6—Effect of lead on vanadium pentoxide.

Factors affecting selection of . . .

Missile Auxiliary Power

Based on paper by

Paul C. Ricks

AirResearch Mfg. Co., Division of the Garrett Corp.

IN internal power for missiles, the trend is definitely toward use of propellant gas turbines. Here are some of the considerations in choosing such systems and their components:

- Weight versus fuel consumption.
- Electrical system requirements.
- Hydraulic demands.
- Turbine diameter and shaft speed.
- Solid versus liquid propellants.

Weight versus Fuel Consumption

In units of higher power and longer operating time, where the fuel weight is a large proportion of the total system weight, heavier, more complex, high-efficiency turbine types of optimum design more than offset their greater weight by reductions in fuel requirements and therefore substantial reductions in total system weight and size. There is usually a "grey" region where a simple turbine type, resulting in a slightly higher total system weight, will be preferred to a more complex higher efficiency turbine system because of such items as cost, and ease of servicing.

Electrical System Requirements

Almost every accessory power unit provides electrical power. The total power level does little to affect the complexity of the unit, but the quality and variations in electrical output are primary considerations in establishing the complexity and reliability of the complete system.

Close frequency control over a considerable load range requires a complex speed control system, while close voltage control requires the addition of voltage regulators. Present state of the art permits frequency control to within $\pm 3\%$ over a 0-100% load range, $\pm 2\%$ over a 50-100% load range, and $\pm 1\%$ at constant load with a fairly simple and reliable speed control. With a complex control system, frequency regulation to within $\pm 0.25\%$ can be maintained over any design load range.

Over small electrical load ranges, permanent-magnet alternators offer advantages in simplicity and light weight and have sufficient inherent voltage regulation for many applications. Since the

output voltage of the conventional permanent-magnet machine is not controlled, it will vary in direct proportion to the alternator speed; therefore, the overall variation in output voltage is the sum of the frequency variation plus the alternator voltage "droop" over the desired load range. Moreover, permanent-magnet alternators are very sensitive to power factor so that variations in it also increase the overall voltage range. Where the electrical load variation exceeds 70-100%, extra permanent-magnet alternator weight is required to provide sufficient inherent regulation for proper overall voltage control ($\pm 5\%$).

Present trends indicate voltage regulation to be generally more critical than frequency regulation and that when electrohydraulic output is required, very large changes in load can be expected. These trends favor the use of alternators with a controllable electromagnetic field which can be adjusted automatically to eliminate the effect of frequency on output voltage and compensate for the normal voltage "droop" when changes occur in electrical load.

Duty cycle and alternator frequency are primary considerations in sizing an alternator for power supply use. High-frequency (800-10,000 cps) allows high rotational speeds with attendant reduction in size and weight. The duty cycle will determine the thermal capacity required of the alternator to avoid overheating, hence will determine the weight of materials in the alternator. External cooling by fuel or other means either can increase considerably the operating duty cycle or generally reduce the alternator weight of a given duty cycle. An example of how high frequency and short duty cycle (uncooled) affect alternator size is found in a 650-w, 4800-cps, 48,000-rpm alternator weighing 1.3 lb.

When d-c power is required, rectification of high-frequency a-c power will show considerable advantage over d-c generators in almost every case. A popular electrical output for conversion to d-c is 5000-cps single-phase a-c. At this frequency, a high-speed alternator can be quite small and light, conversion efficiency is high, ripple is nil, and filtering is relatively simple.

Hydraulic Demands

The hydraulic system demand on units requiring hydraulic power is usually such as to require steady-state power at a low level and transient power at a considerably higher level. In selecting the best components to meet the requirements, various pump and accumulator combinations must be reviewed to

see which results in minimum system volume and weight.

Fig. 1 represents a typical hydraulic system demand schedule, in this case showing zero steady-state power level. The first step is to translate the hydraulic requirements, as shown in this figure, to total volume of hydraulic fluid required as a function of flight time (Fig. 2). The fluid requirements compared with various hydraulic pump capacities make possible determining the accumulator volume required for any given pump capacity. The accumulator volume is then plotted as a function of pump capacity. Since pump capacity determines to a large extent the power level of the system, it is also possible to establish propellant volume as a function of pump capacity. By combining accumulator, reservoir, propellant and pump volumes, it is possible to prepare an optimization curve of total hydraulic system volume as a function of pump capacity as shown in Fig. 3. Using this curve and considering secondary effects such as pump heat rejection, control system complexity, and packing restrictions, a pump-accumulator combination is selected to provide the smallest practicable hydraulic system.

Hydraulic pumps fall into two general categories, fixed displacement and variable displacement. Each has advantages and disadvantages. The fixed type is light in weight, but cannot of its own provide for the peak hydraulic demand unless the system is capable of absorbing the considerable quantity of work, as heat, generated by pump operation during the minimum demand regime, but sized to meet maximum demand. Considerable reduction in heating is possible by the use of a pump unloading valve.

The variable-displacement pump can provide, within limits, for both the steady-state and transient requirements, but the variable types are usually heavier than the fixed displacement pumps of the same maximum capacity. Moreover, the transient to steady-state requirements ratio may be such as to prohibit the use of the variable type without an accumulator because pump response time is incompatible with system requirements. Also, the prime mover must be capable of supplying the maximum peak power requirements with the variable-displacement pump.

Light-weight and very efficient versions of the conventional aircraft axial piston pump have been

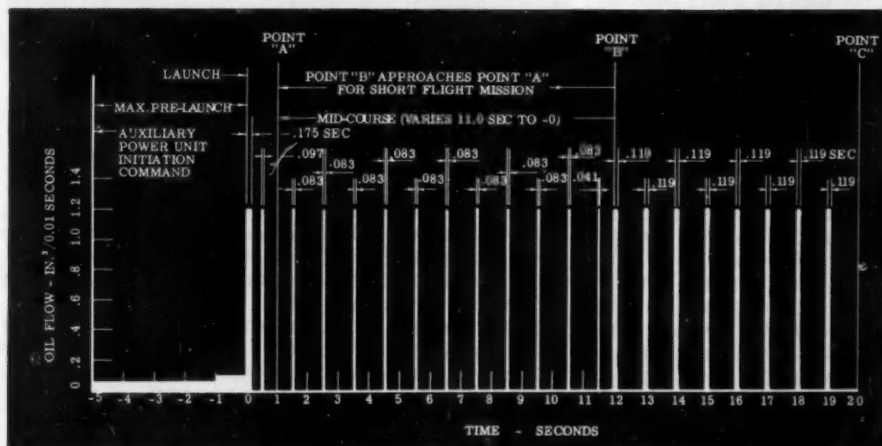
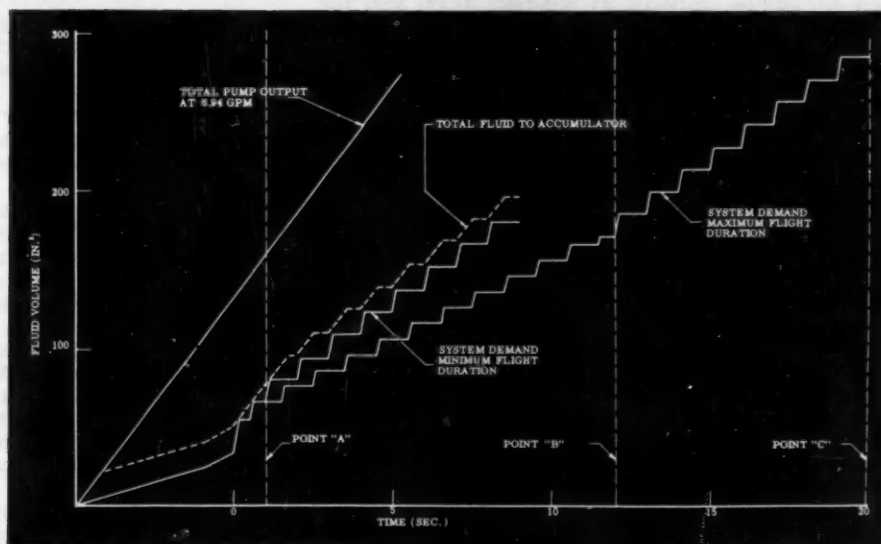


Fig. 1—Typical hydraulic system demand schedule here shown at zero steady-state power level.

Fig. 2—Hydraulic requirements, as shown in Fig. 1, translated into total volume of hydraulic fluid required as a function of flight time.



developed recently which can be operated at relatively high speeds for short duration (up to 18,000 rpm for one hour). Pumps of this type are used on many recent APU designs, particularly for duty cycles in excess of 60 sec, or where the hydraulic power level is so high as to make efficiency an important consideration. It is expected that piston-type pumps, including the variable-displacement type, will be operated at increasingly higher rotational speeds, and that miniature variable- and fixed-displacement pumps with ratings in excess of 20 gpm will be developed to meet hydraulic requirements of future missiles. Most present missiles require 1-5 gpm fixed-displacement pumps.

Centrifugal Pump Possibilities

A centrifugal pump which can be driven directly at turbine shaft speed is an interesting possibility. Although admittedly less efficient than a piston-type pump, the weight saving and increased reliability might justify its use. It would exhibit performance similar to that of a variable-displacement pump in delivering essentially constant head over a very wide range of flow. Application might be where very high peak hydraulic loads are met for short periods, so that the efficiency of the unit would be less important than minimum size and weight.

Prime Mover Component Selection

Selection of prime mover components follows tentative establishment of prime mover load components. Compromise with performance, structural limitations, and reliability determine the turbine diameter and shaft speed. Usually it is desirable to limit shaft speeds to a maximum of 60,000 rpm to attain proper bearing life and unit reliability. Turbine performance (in the range of most missile power units) is substantially proportional to the turbine peripheral speed, therefore, from a performance standpoint it is desirable to have the largest possible diameter for any given shaft speed. However, restrictions in turbine peripheral velocity are imposed by structural considerations to values of 1000-1200 fps. Additional restrictions in diameter are sometimes imposed by windage losses and the allowable envelope for the unit.

Propellant gas turbines for missile APU applications are characterized by relatively low power output (1-70 shp) with very high adiabatic heads (up to 700,000 ft-lb per lb) leading to low specific speeds and low efficiency. Efficiency has been less important than durability or minimum weight in most applications, and single-stage, partial-admission impulse turbines of various types (axial-flow, radial-flow, terry turbine, and others) have been used with essentially equivalent performance.

The very high adiabatic heads suggests the use of pressure staging to gain more nearly optimum velocity ratios and higher overall efficiency. However, the theoretical thermodynamic gain with increasing number of stages will be offset by increasing disc friction losses and increasing turbine weight. The optimum turbine design depends on the power level and length of duty cycle. In general, a single-stage turbine will be optimum for energy outputs of less than about 100 hp-min, a 2-stage optimum in the range 100-500 hp-min, and a three-stage optimum above 500 hp-min.

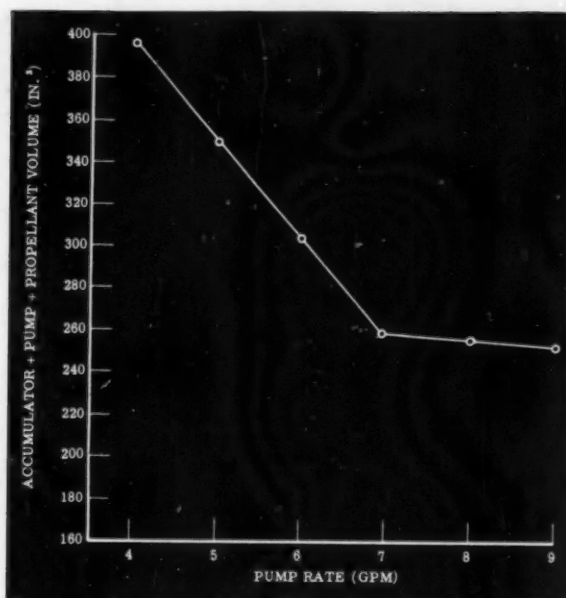


Fig. 3—Optimization curve of total hydraulic system volume as a function of pump capacity obtained by combining accumulator, reservoir, propellant, and pump volumes.

It should be possible to attain a specific fuel consumption of about 8 lb per shp-hr for a 3-stage turbine wheel, and 10 lb per shp-hr for a 2-stage wheel using ethylene oxide at a power level of 50 shp at altitude (turbine discharge pressure is equal to 1 psia). A 20% reduction in such consumption would be expected with hydrazine.

Turbine shaft speeds up to 120,000 rpm are used on AiResearch refrigeration turbines. But in the interest of gear design and reliability, shaft speeds are restricted to lower values for APU applications.

Choice of Propellants

The gas generator of a propellant gas turbine can be regarded as a miniature rocket motor in which the exhaust gas is directed at the blading of a turbine wheel, which in turn applies torque to the turbine shaft. For relatively short-duration units (60 sec or less) solid propellant gas generators offer simplicity and compactness. The main disadvantages of solid propellants are the inability to start and stop as required by some irregular duty cycles, and the relatively fixed grain size required for any particular application, which may cause packaging restrictions.

The liquid monopropellant gas generator allows considerable flexibility in packaging, since the required fuel volume can be contained in a tank of practically any shape. Moreover, it has the advantage of being able to start and stop as required by merely controlling the fuel flow to the generator. The primary disadvantage is relatively high dead weight (for short duration units) and complexity.

To Order Paper No. 213 . . .

. . . on which this article is based, turn to page 5.

A Turbine-Powered Car Might Win at Indianapolis

IN THIS ARTICLE, a Boeing engineer draws on his company's unique experience with gas turbine engines in ground vehicles to back up with specific data his claim that:

"The equipment and the know-how are available right now to build a turbine racing car that would not only be a serious threat at Indianapolis, but would stand a very real chance of winning."

Based on paper by

Leonard H. Williams,

Boeing Airplane Co.

A BOEING 502-10F turbine (Fig. 1)—placed in a racing car especially designed for it—will result in a combination that will be pretty hard to beat in a 500-mile race on the Indianapolis Speedway.

Analysis of this gas turbine powerplant—rated at 300 hp and 5680 output shaft rpm—shows why a turbine fits so well into the racing business. Horsepower and torque curves are shown in Fig. 2.

This is a "hot rodder's" version of the standard production 502-10C, which is rated at 240 hp at 5160 rpm.

Hopping up a turbine consists of making it run faster and hotter. This, in turn, is accomplished by increasing the fuel nozzle pressure and opening the gas flow nozzles. As with the piston engine, this in-

crease in horsepower is accompanied by a corresponding decrease in engine lift.

The life of this 502-10F engine at full power is estimated to be more than ample for Indianapolis race requirements. An additional 15 hp can be gained at 175 mph by taking advantage of the ram effect of the air.

Figs. 3 and 4 show what can be expected in the way of performance from a turbine-powered racing car.

Turbine, Piston Cars Compared

Fig. 3 shows the available tractive effort and drag curves of both the turbine car and the piston engine car versus miles per hour. Gear ratios chosen for both cars allow the engines to develop their peak

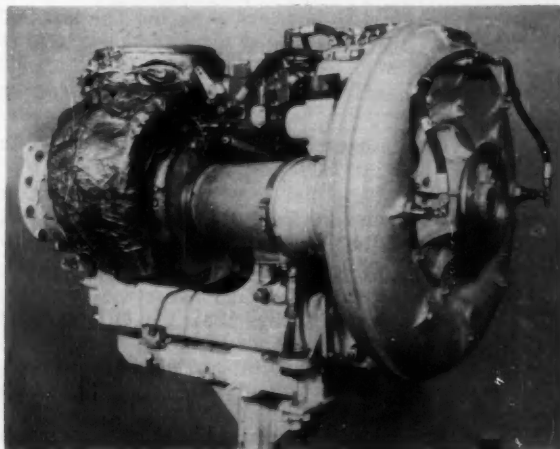


Fig. 1—Using this gas turbine in a racing car specifically designed for it, the author says, "will result in a combination pretty hard to beat in a 500-mile race on the Indianapolis Speedway." (It's Boeing's 502-10F.)

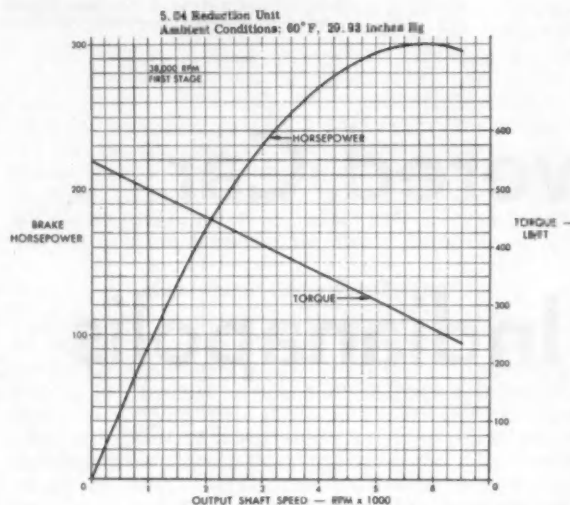


Fig. 2—Horsepower and torque curves for Boeing 502-10F gas turbine engine.

power at 165 mph. This approximates conditions at the track and gives us a fair basis for comparison. As the curve shows, the higher horsepower of the Offenhauser engine gives it a higher top speed and greater acceleration in the high-speed range. But below the high-speed range the torque characteristics of the turbine give it a pronounced edge in acceleration. This torque advantage is down in the speed range where the cars are coming onto the straightaway.

Fig. 4 is based on the tractive effort and drag curves shown in Fig. 3 and on the following assumptions:

1. The cars start to accelerate during the last 500 ft of the turn and continue to accelerate for 3300 ft of the straightaway for a total of 3800 ft.
2. The cars start to accelerate from a speed of 125 mph.
3. The Offenhauser-powered car weighs 1700 lb and the turbine-powered car weighs 1375 lb.
4. The effect of the inertia of the rotating masses such as the wheels, shafts, and gears is accounted for by adding 5% to the total mass.

The results show that the torque characteristics of the turbine will enable it to cover the distance approximately 0.25 sec quicker than the Offenhauser and to be ahead by a distance of 65 ft. This shows that, even though the turbine car is underpowered, it has the low-speed torque advantage and the light weight necessary for good acceleration.

A practical demonstration of this point was shown in a drag race between two Kenworth trucks several years ago. One was powered by a Boeing 175-hp turbine and the other by a 200-hp diesel. Both

trucks were loaded to the same gross weight. Because of the low-speed torque of the turbine it was ahead by about three truck-and-trailer lengths at the end of half a mile. However, the extra horsepower of the diesel gave it a higher top speed and after both trucks had reached their top speed, the diesel eventually caught and passed the turbine.

One critical disadvantage of the turbine is the amount of time required for the gas producer rotor to accelerate from idle rpm to full power. In the Model 502-10F gas turbine, this is about 3 sec.

Acceleration Lag Problem

This problem may not be as serious as it sounds. In a race like Indianapolis, instantaneous response and sudden bursts of speed are not required as much as they would be in a race of shorter duration on a small track. Indianapolis is a race where the driver finds the "groove" and maintains a high average speed to win. In driving the turbine the driver will learn to anticipate power requirements and will know at what point to apply the throttle to maintain a high average lap speed. This is not the first time this problem of accelerating lag has shown up at Indianapolis.

In the event that the drivers are unable to cope with this acceleration lag there is another way to overcome it. A wastegate power control between the gas producer turbine wheel and the output section turbine wheel will allow the high-velocity gas to bypass the output turbine wheel while the gas producer is turning at about rated speed. When the wastegate closes, the gas is again directed against the output turbine wheel and the torque response is instantaneous. This method has been used successfully on several Boeing turbine applications.

Another advantage of the turbine over its 4-cyl counterpart is its smooth torque flow. The destructive qualities of the pounding power surges of the four cylinders are only too well known to be reiterated here. The turbine's smooth torque flow will make itself felt not only in increased life of the driveline components but also in lessening of driver fatigue, an important factor in a 4-hr race.

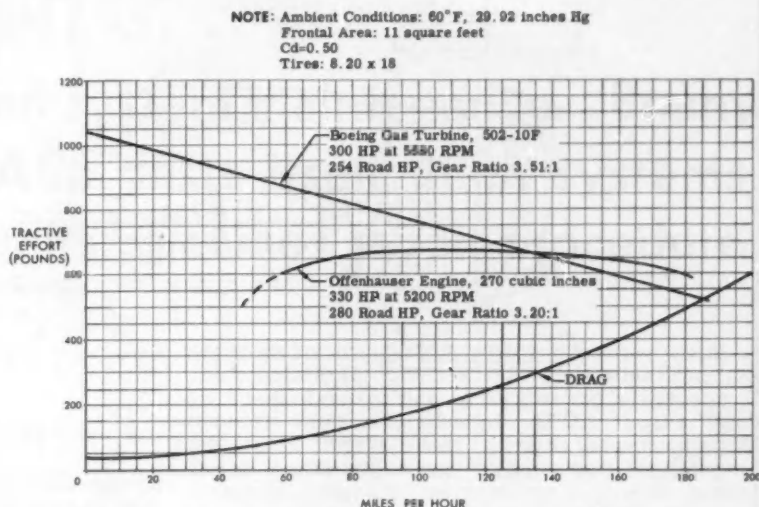
Less Vibration in Turbine

The absence of vibration also means the chassis and driveline system can be of lighter construction, thereby effecting an additional weight saving. (In all cases where gas turbines have replaced piston engines in helicopters, the life and reliability of the delicate and expensive transmission have been increased many fold.)

Another important effect of the smooth torque flow is in the increased ability of the tire to transmit torque to the ground. The turbine approaches the traction limit of the tires gradually and the tires are less likely to break free.

The turbine provides absolutely no vehicle retarding force. There have been methods suggested for using the compressor as a power-absorption device, but all methods are both complicated and at the present time unproved. In this installation, all braking will have to be done by the wheel brakes. The condition of the spot brakes now being used at

Fig. 3—Available tractive effort and drag curves versus mph for turbine-powered car and piston-engine-powered car. (Gear ratios used for both cars allow engines to develop peak power at 165 mph.)



the end of 500 miles indicates that they are more than ample for their present job and should be able to handle the job of slowing down the turbine car. If not, higher capacity brakes could be developed.

Today's turbines are selling for about \$14,000. This is a little more than twice the cost of the Offenhauser engine. While this price is high, it is not unreasonably high to the extent that it places the turbine completely out of reach of the race-car owner. This price is, of course, being substantially reduced as the production of gas turbines increases.

Engine-Chassis Arrangement

Fig. 5 shows one possible arrangement of the engine and chassis. The chassis shown is a Kurtis 500D. Later refinements of the chassis and suspension culminating in the 500F can also be incorporated in this design. The engine fits in quite nicely with the standard 6-in. offset. Cooling air coming in the front would be divided between the oil cooler and the engine compartment. The air inlet is located on top of the engine compartment to prevent the influx of dirt and rubber from the track. The installation is shown with a simple dog clutch to couple the engine to the driveline. Because the turbine has its own built-in torque converter the standard 2-speed transmission is not required. The dog clutch could be replaced with a marine reverse gear if reverse is required. For the ultimate in reliability the conventional Indianapolis clutch and transmission with one gear removed could be used.

Turbine Exhaust Problem

The turbine exhaust has always been a problem. The exhaust gas temperature is 1150 F and requires a duct with a cross-sectional area of 80 sq in. In this

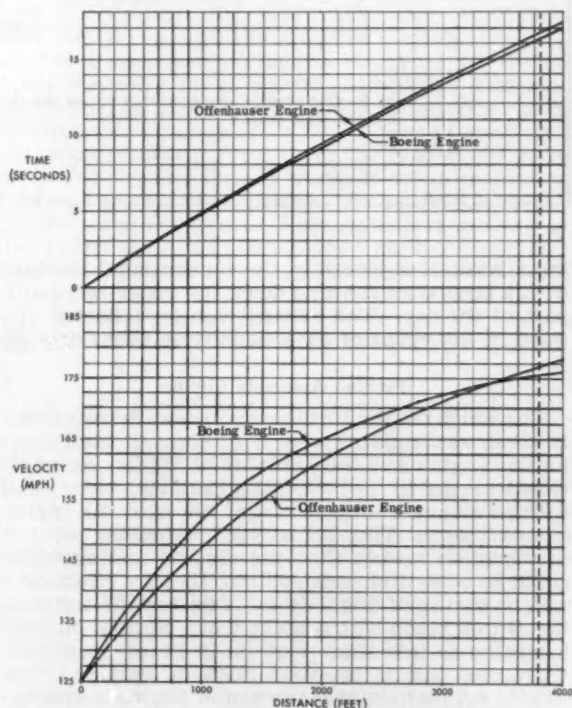


Fig. 4—Data based on tractive effort and drag curves given in Fig. 3 show that torque characteristic of the turbine will enable it to cover distance of 3800 ft approximately 0.25 sec quicker than piston-engined car with which it was compared.

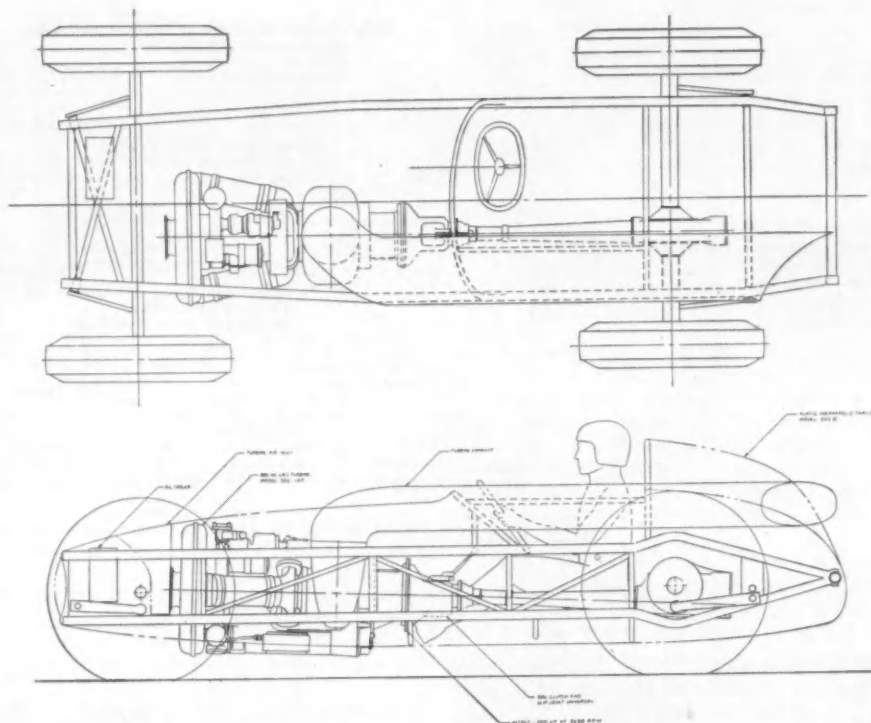


Fig. 5—One possible arrangement of engine and chassis in which Boeing 502-10F turbine engine is mounted in Kurtis 500D chassis.

installation it is placed in the conventional location with a large duct running down the upper-left-hand part of the car. The exhaust can be deflected upward in the event of objections from other drivers.

Turbine Assembly Lighter

The weight of the turbine engine and transmission is 425 lb as compared with the weight of the Offenhauser engine and transmission of 550 lb. An additional saving of 75 lb for the radiator, water, and fittings means a total saving of 200 lb in the engine compartment. This lighter engine and the absence of vibration means that the chassis and driveline could be of lighter construction, thereby effecting a weight saving of about 50 lb. The turbine contains its own oil sump which holds 6 qt. Normal oil consumption is less than 1 qt in 15 hr of operation; therefore, this is all that need be carried. The weight saving here over the piston engine is approximately 8 gal of oil plus the oil tank which is estimated to be 75 lb. This makes a total weight saving of 325 lb. This will have a tremendous effect on tire life, a problem that has plagued race-car drivers for years. It also means increased acceleration. Less weight in the forepart of the car means a change in weight distribution. This can be compensated for

by locating the fuel tank amidship instead of over the rear axle, as has been done on the Italian Lancia and several other European cars. This position provides the desirable characteristic of having a constant weight distribution with either a full or empty tank. This midship position has often been criticized by drivers as being a potential fire hazard in the event of an accident. It should be remembered at this point that the turbine uses diesel fuel and not highly explosive gasoline or methanol.

Previous Model Reviewed

The famous SAC Firebold had a Boeing Model 502-8C 175-hp turbine installed in a Kurtis 3000 series chassis. The car turned a speed of 107 mph in 13.4 sec in a standing quarter mile. Time and speed were recorded during the 1955 National Drag Meet at Great Bend, Kans. This car also made a demonstration run at Indianapolis just before the 1955 race, which could very well be considered symbolic of things to come.

To Order Paper No. S23 . . .

... on which this article is based, turn to page 5.

Automation . . .

...reaches weapon system maintenance. Brainy device, called RACE, tests itself, then systems, identifies faulty units, specifies repair procedure.

Based on paper by

Arthur J. Morrow

Sperry Gyroscope Co., Division of Sperry Rand Corp.

AUTOMATION of maintenance equipment can be used to cut cost and down-time of weapon systems. Low skilled personnel can O.K. a system or pinpoint its faults, turning repairs over to the skilled expert.

RACE (Rapid Automatic Checkout Equipment) is such a tool, produced by Sperry Rand. Here's how it works:

Primary tests are designed to make an overall system test or tests on as large a part of the system as possible. In case the system fails to pass, that is "no-go," malfunction isolation tests, called secondary tests, are designed to spot the faulty line replaceable unit.

Automation is achieved by programming the sequence of primary tests and supplying the output of suitable comparators to a logical decision unit which determines which secondary tests, if any, should be performed. This procedure assures rapid checkout of the system. In addition, the equipment incorporates features in the indicating device to supply information contributing to the solution of the logistic support problems.

A block diagram of the equipment required in a system such as RACE is shown in Fig. 1. The programmer and subprogrammer coupled with memory form the master control. This conforms with high-speed digital computers, which also are controlled by the programmer coupled with memory. The same types of equipment and digital techniques used in digital computers can then be used in the master control of RACE. This equipment is punched on magnetic tape readers or punched card readers for the programmer and subprogrammer and magnetic drum, magnetic core matrix, delay lines, diode matrix, and others, for the memory unit.

The operation of RACE is initiated by the programmer. First comes a self-test of RACE. The programmer sends command signals to the signal generators, memory, and the channel selectors. As the system under test responds to the input signals, transducers convert, where necessary, each of the outputs of the system to a d-c voltage or to a digital output proportional to a particular system parameter. The channel selector chooses these signals in

sequence for comparison with a reference signal in the comparator. The result of the comparison is a go/no-go signal which is sent to the programmer, memory, and fault indication. If the signal is "go," the programmer will continue with the primary test. If the signal is "no-go," memory and the subprogrammer operate to conduct the proper secondary test sequence until the fault indicator registers "no-go." The operational information is presented on the center screen of the control console and the maintenance punched card is ejected.

The punched card indicates the faulty unit, down-time, spare location, tools required to make repair, and the step-by-step repair procedure to follow. The faulty unit and the punched card can now be sent to a maintenance facility where higher skilled technicians can make repairs, if possible. The card could then be punched with coded information as to the exact defective tube or component at fault and the cause of fault. From there the card would go to a central clearing facility where it could be used as a failure report, as an order in the automatic resupply program, and as an aid for statistical analysis to determine units requiring design improvement and to determine system fault prediction.

To Order Paper No. 209 . . .

... on which this article is based, turn to page 5.

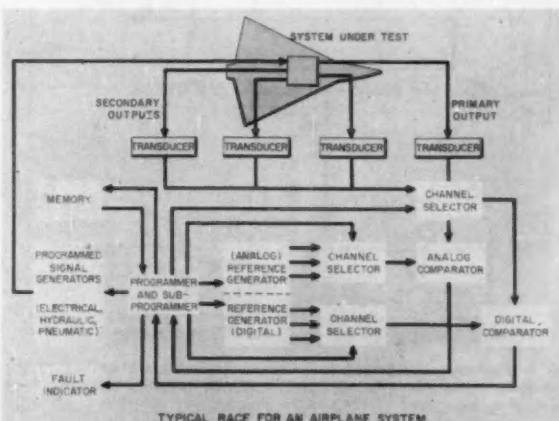


Fig. 1—Block diagram showing variety of types of electronic, electric, and electromechanical equipment required in a system such as RACE for automatic maintenance of weapon systems.

Inelastic Design Steps Up

Aircraft thermal stresses can partially be overcome by allowing limited deformation in the structure. Greatest improvements can be made in missiles.

Based on paper by

G. H. Sprague, Martin Orlando
and **P. C. Huang** Martin Baltimore

MISSILE and airplane structural weight savings are available from inelastic designs for thermal stresses. Taking advantage of temperature gradient shapes can improve the efficiency of the structure within the limits of buckling strength and allowable deformation.

Normal elastic design produces heavy beams when a peaked or recessed temperature gradient is present. The critical fiber stress is rapidly reached at one point while the rest of the structure is relatively unloaded.

Checking an Aluminum Beam

Design limitations were determined by stressing a long, flat, aluminum plate with simply restrained edges. A theoretical investigation and experimental verification were performed. The aluminum was 2024-T4. During the experimental test a high and constant loading rate was used to preclude significant creep and provide consistent data.

The plate configuration is shown in Fig. 1, along with the two theoretical temperature distributions used. The distributions represent cooling (peaked gradient) and heating (recessed gradient) of a wing beam.

Design Investigations

For both tension and buckling loads the following points must be checked:

- Inelastic stress distribution for combined thermal and external loads.
- Residual stress patterns produced by inelastic loadings.
- Deformations produced by inelastic loadings.
- Tensile and buckling strength after repeated inelastic loadings.

One-Shot Inelastic Tensile Loadings

Varying thermal stresses tend to level out under inelastic tensile loadings, as shown in Fig. 2. This

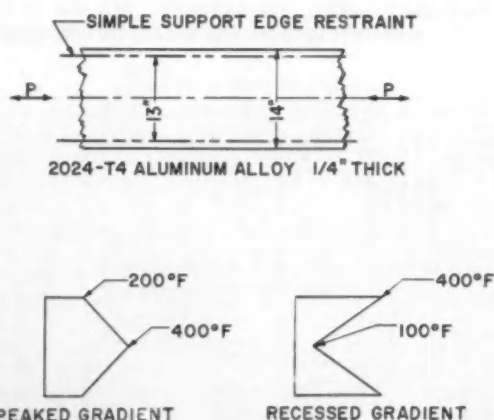


Fig. 1—Peaked and recessed temperature gradients are applied to the test plate. Inelastic behavior under external loads is calculated and checked by tests.

Performance

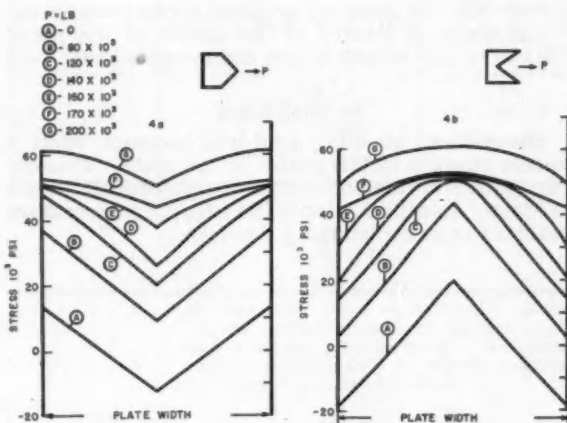


Fig. 2—Nonlinear thermal stresses decrease in magnitude as external tensile loadings produce plastic deformations.

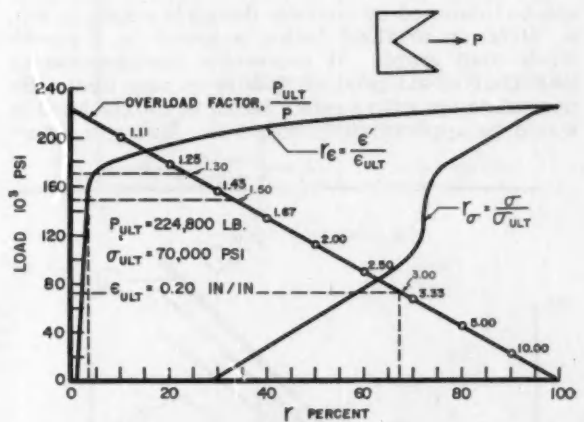


Fig. 4—Structural performance of the test plate is based on actual ultimate failing stress. The ultimate strain is arbitrarily taken as 0.20 in. per in. The overload factor is the inelastic equivalent of a safety factor for tensile loads.

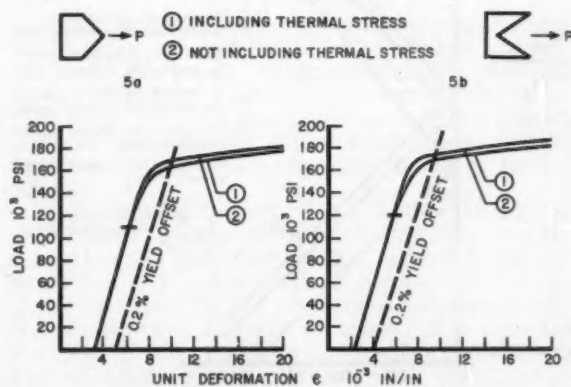


Fig. 3—The effect of plastic deformation on a thermally stressed plate materially lowers the elastic limit of the plate, but does not cause excessive deformation.

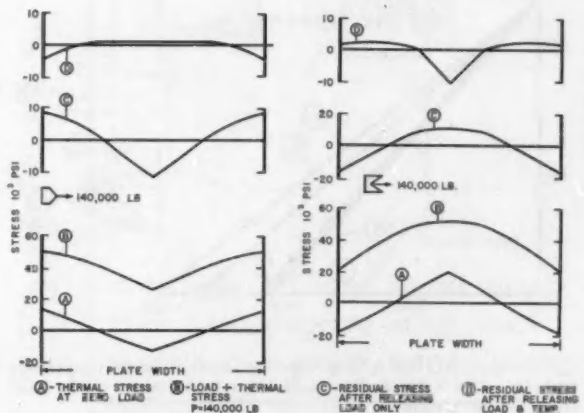


Fig. 5—Residual stress patterns are the reverse of thermal stresses that cause them. The test panel is under a tensile load.

means that failure of the plate in tension will not depend on the temperature distribution, but will follow closely the failure anticipated for the material at its average temperature. The difference in performance before failure for these two conditions is shown in Fig. 3. Here, the unit deformation starts earlier for a plate with a temperature gradient, but does not veer off sharply. This permits an increased loading of the thermally stressed plate before excessive permanent set occurs.

In calculating the above curves, equations of equilibrium and compatibility of strain are used, along with the concept that stress equals the product of the secant modulus and the effective strain. The calculations are iterative except if the structure is entirely elastic, in which case the solution is immediately exact.

An example of how structure tensile performance can be increased by inelastic design is shown in Fig. 4. Here, an overload factor is scaled on a stress-strain-load graph. It represents the increase in load that would produce failure in any fiber. By normal design with a safety factor of 1.5, the loading would be approximately 95,000 lb. Using an over-

load factor of 1.5 gives a beam strength of approximately 150,000 lb. Fig. 3 shows that the unit deformation of the structure is still below the accepted 0.2% offset yield point.

Residual Stress Caused by Tensile Loadings

Inelastic tensile loadings affect future compressive loads and deformations rather than the static tensile failing load. Residual stresses resulting from tensile loading are calculated as a history for buckling and deformations.

The residual stress is calculated by first applying an equal and opposite external load to the deformed structure and calculating the resultant stress distribution. A similar procedure is followed for the thermal stress. The results for peaked and recessed thermal gradients are shown in Fig. 5. The residual stress tends to be opposite to the original thermal stress. For the recessed gradient a compressive residual stress is formed in the center of the plate. This adversely affects future compressive loads.

Buckling Loads

The critical buckling load will increase when a tensile stress is in the center of the plate. This occurs with the recessed temperature gradient shown in Fig. 6. Also illustrated is the effect of temperature gradient rates on buckling strength.

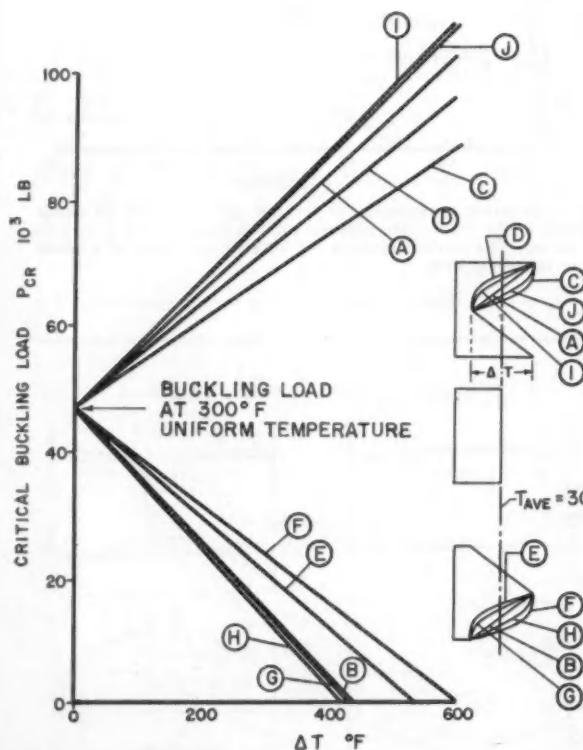


Fig. 6—Panel buckling is only improved under recessed temperature gradients. This is due to the tensile stress in the center of the panel caused by this gradient.

Triangular shaped gradient causes panel instability due to high-magnitude thermal stresses in the middle of the panel. The highly curved gradients give more even temperature distribution over the panel. Both effects bring the critical buckling strength nearer to the constant-temperature condition.

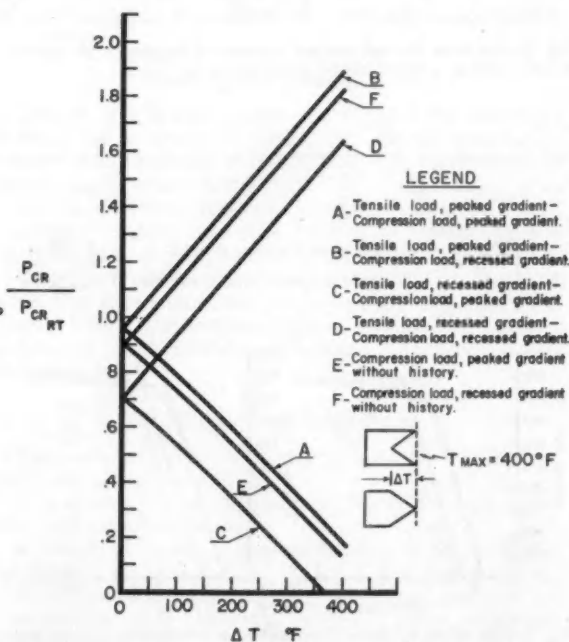


Fig. 7—Residual stress history of the panel moves the critical buckling load. The benefits possible are small compared to the possible loss in buckling load. After a series of repeated random thermal loads, it is expected that the critical buckling load will continue to decrease.

MISSIONS	TRANSVERSE TEMP.	LOAD
O A	<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;">200 °F</div> <div style="width: 20px; height: 20px; border: 1px solid black; margin: 0 5px;"></div> <div style="text-align: center;">400 °F</div> </div>	140,000 LB TENSION
A B	<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;">400 °F</div> <div style="width: 20px; height: 20px; border: 1px solid black; margin: 0 5px;"></div> </div>	140,000 LB TENSION
B C	<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;">400 °F</div> <div style="width: 20px; height: 20px; border: 1px solid black; margin: 0 5px;"></div> <div style="text-align: center;">100 °F</div> </div>	140,000 LB TENSION
C D	ROOM TEMPERATURE	140,000 LB TENSION
D E	<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;">200 °F</div> <div style="width: 20px; height: 20px; border: 1px solid black; margin: 0 5px;"></div> <div style="text-align: center;">400 °F</div> </div>	140,000 LB TENSION

Fig. 8-A

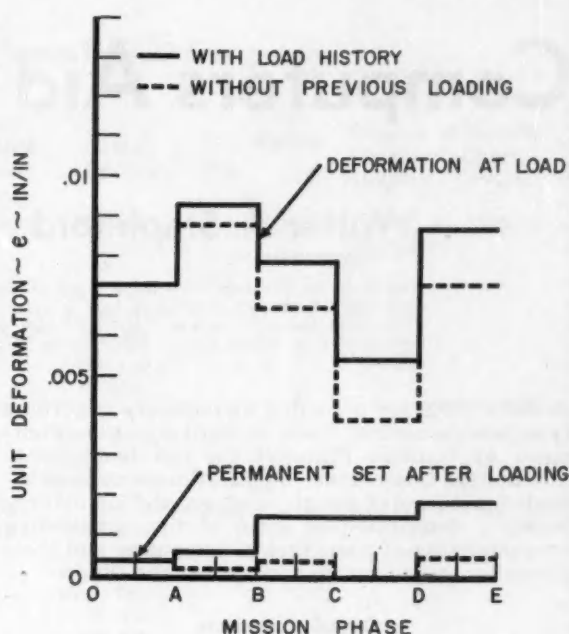


Fig. 8-B

Fig. 8-A, B, C—Series of airplane missions show the cumulative effect on deformation, permanent set, and buckling strength for the test panel. In each case, the panel performance was decreased after the missions. Only the ultimate tensile load is not affected by repeated loadings.

The shift in critical buckling load due to a residual stress history is shown in Fig. 7. Here a compressive stress in the middle of the panel decreases the buckling strength.

Repeated Loads

Decreased buckling strength and increased permanent set can occur after a series of thermal and tensile loads. This is due to the development of an adverse residual stress and deformation history.

In using inelastic design techniques, this history must be calculated for expected loading to prevent excess set, super-critical buckling loads, or fatigue failures.

An example of the effect of a residual stress history is given in Fig. 8. Peaked, uniform, and recessed temperature gradients are applied to the test panel during a uniform tensile loading. At the end of the last loading, the permanent set is increased and the buckling strength decreased. It is expected that similar subsequent loadings will not produce as marked a reduction in performance.

The use of inelastic loadings must therefore be tempered by the calculation of the history of repeated loads.

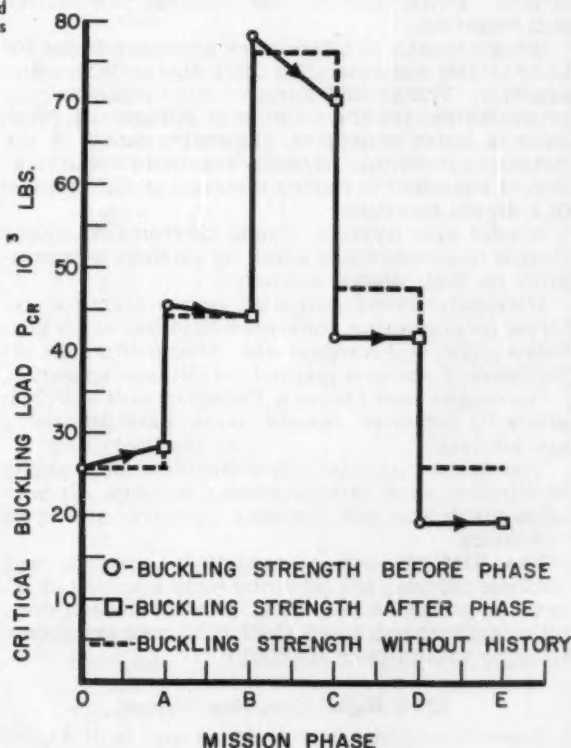


Fig. 8-C

To Order Paper No. 212...

... on which this article is based, turn to page 5.

Computers Aid Process Control

Based on report by **Walter A. Stapleford,**
Thompson Products, Inc.

Report of the Computer Applications Clinic at the 12th Annual ISA Instrument-Automation Conference held at Fenn College, Cleveland. The information in this article is available to SAE members due to the efforts of T. R. Thoren, Special Advisor to the SAE President on Computers.

COMPUTERS are becoming increasingly important in process control, it was brought out at the Computer Applications Clinic of the ISA Instrument-Automation Conference. Applications discussed included problems of design, analysis, and simulation. Here's a description of some of the outstanding characteristics of some typical computers and their accessory equipment, as revealed at the Clinic.

Digital Computers

All of the digital computers listed in the table on the adjacent page, with the exception of the IBM 650 and the Burroughs Datatron, are designed primarily for complex scientific and engineering calculations, rather than routine business calculations and reporting.

Bendix Computer offers a new accessory device for their G-15D computer, the DA-1 digital differential analyzer. This special-purpose equipment, on which programming for the solution of differential equations is much simplified, eliminates many of the complex subroutines normally required for the solution of equations involving integrals or differentials in a digital computer.

Bendix also offers a simple interpretive coding system to simplify and speed up problem programming on their digital computer.

Burroughs E-101 computer provides simple external programming, conventional 10-key adder keyboard input, and compact size. It also offers the alternative of operator manual over-ride or operation.

Burroughs also makes a Datatron unit which is primarily oriented toward large data-processing applications.

The Alwac computer offers complete adaptability to punched-card data-processing systems. It contains automatic self-checking circuitry, and error indicators.

The IBM 650 can be applied to scientific and business calculations requiring large amounts of input-and-storage access data. It exhibits high overall computational speed (including memory access, transfer to-and-from memory).

Other Digital Computing Systems

Ramo-Wooldridge has designed and built a general-purpose digital computer, the RW-300, which when used with accessory equipment may be used as part of a process-control system. The system

accepts up to 300 inputs of digital or analog information, with up to 150 control command outputs. The computer is completely transistorized and features compactness of size, high reliability, and durability.

Daystrom offers an Operational Information System utilizing all solid-state components, analog to digital converters, and magnetic-core computer memory designed specifically for industrial-data processing and "on stream" computation, and control in continuous-process industries.

Analog Computers

Analog computers, as a class, have certain advantages for scientific and engineering calculations involving dynamic, rather than static system analysis. They are not suited for essentially digital computations or those involving large quantities of input data, such as data reduction, matrix inversion, or linear programming. Their accuracy is within $\pm 0.5\%$.

An analog computer permits direct electronic simulation of a physical or chemical system on the computer, whereby the differential equation describing the dynamics of the computer circuit are of the same structure as the equation describing the dynamics of the system under study.

Parameters in the system are set by externally controlled potentiometers and thus may be varied easily. Such an arrangement is of advantage in the design of control systems and of any mechanism or component subject to instability which must operate under varying conditions or must produce a continuously varying output.

Actual parts of the control hardware may be wired into the computer for direct study, or both the system to be controlled and the control system may be simulated. Differential equations are solved directly and the time solution plotted to any desired scale, without requiring any knowledge of the mathematical means of solution, except for checking purposes.

Goodyear Aircraft's A-14 Electronic Differential Analyzer is an analog computer with a compact, integrated unit design, and built-in program check circuits.

The Philbrick computer is sold by individual components, to make up an analog computing system of any desired size and complexity. This arrangement is said to be advantageous for applications requiring less than 50 operational amplifiers in the computer system.

Design Characteristics of Some Typical Computers

Computer Manufacturer	Computer Designation	Computer Type	Input Devices	Add Speed (per sec.)	Output Devices	Programming		Internal Memory (words)	Automatic Check Circuits
						Int.	Ext.		
Alwac Corp.	ALWAC III-E	Digital (fixed pt.)	*Cards—100 per min.	1000	*Cards—100 per min.	Tape	—	8,192 (10-digit)	Yes
			Mag. Tape—1000 char. per sec.		Mag. Tape—10,000 char. per sec.				
			Paper Tape—200 char. per sec.		Paper Tape—60 char. per sec.				
			Flexowriter		Flexowriter—10 char. per sec.				
Bendix Computer Div. of Bendix Aviation	G-15D	Digital (floating pt.) (differential analyzer)	*Cards—12 per min.	1500-2000	*Cards—8 per min.	Tape	—	2,160 (7-digit)	No
			Mag. Tape—430 char. per sec.		Mag. Tape—430 char. per sec.				
			Paper Tape—60 char. per sec. (Hi-speed—225 char. per sec.)		Paper Tape—60 char. per sec. (Hi-speed—225 char. per sec.)				
			Typewriter		Typewriter—8 char. per sec.				
Electro Data Div. of Burroughs Corp.	E-101	Digital	Keyboard—(Similar to desk comp.)	20	Typed digits—24 char. per sec.	—	Tape Pin boards	100-200 12 digits (data only)	No
			Tape—20 char. per sec.		Tape—30 char. per sec.				
Electro Data Div. of Burroughs Corp.	Datatron	Digital	Cards—60 per min.	500	Cards—60 per min.	Cards	—	4080 (10-digit)	?
			Paper Tape—540 char. per sec.		Paper Tape—60 char. per sec.				
			Man. Keyboard		Visual Display				
			Typewriter		Typewriter—10 char. per sec.				
IBM	650	Digital	Cards—200 per min. (Card-punch)	1300	Cards—100 per min. (Printer)	Cards	—	2000 (10-digit)	Yes
Goodyear Aircraft	GEDA A-4	Analog	Patch Board	—	Brush Elec. Recorders Typewriter	—	Patch Board	—	Manually operated

*by use of external converters

New Research Tool

Aids Combustion Analysis

Based on paper by

J. A. Robison, M. D. Behrens,
R. G. Mosher, and J. M. Chandler

Ford Motor Co.

AN instrument has been developed for measuring quantitatively the cylinder pressure development of both normal and abnormal combustion in unmodified engines. It also provides a more fundamental means for categorizing the various types of abnormal combustion inaudible or indistinguishable to the human ear. It is low in cost and inexpensive to maintain.

Basically, the tool consists of a spark plug containing a passage leading from the combustion chamber to a pressure sensing element (Fig. 1). The combination is constructed in two units to facilitate the replacement of damaged or fouled spark plugs and to maintain a fixed clearance at the indicator end of the passage. The spark-plug unit, which can be produced at low cost, consists of a standard spark plug, stainless-steel tube, and a small brass adapter. The shell of the spark plug is drilled to accept the tubing. The tubing and

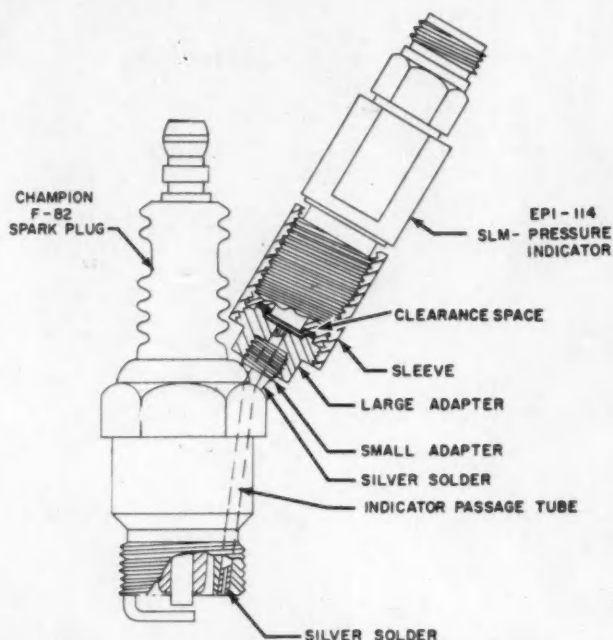


Fig. 1—Cross-section of spark-plug pressure-indicator combination, a tool for studying combustion phenomena which is low in cost and inexpensive to maintain.

adapter are silver soldered in place. Application of the indicator passage principle on virtually any spark plug appears feasible since it is permissible to allow the indicator tube to pass outside the spark-plug shell above the spark-plug seat. The indicator unit consists of a pressure indicator, large brass adapter, and brass sleeve. The pressure indicator used in these investigations is a Kistler SLM quartz crystal pickup—model EPI-114. The large brass adapter is machined to follow the contour of the end of the pressure indicator with a minimum of clearance. The sleeve joins the adapter to the indicator. The indicator unit remains intact with fixed clearance until maintenance is required.

It is necessary to have sufficient adapter-to-indicator clearance height to guarantee free movement of the pressure-sensing element. However, too great a clearance results in excessive pressure oscillation and dampening, while too small a clearance may interfere with the normal actuation of the pressure-sensing element. Approximately 0.001-in. clearance at ambient temperatures was necessary to compensate for metal growth at firing temperatures and to permit free operation of the pressure-sensitive element. There have also been instances where deposits have accumulated in the clearance space to an

extent where the action of the pressure-sensitive element was hampered.

Effect of Indicator Passage Dimensions

The effect of indicator passage diameter was determined over a range of engine conditions including variations in speed, throttle, spark timing, fuel flow, and during autoignition. Spark-plug units with $1\frac{1}{2}$ -in. length passages and diameters of 0.040, 0.032, and 0.025 in. were tested. The same indicator unit was used throughout the test. Use of the 0.040-in. diameter passage resulted in pressure oscillations and pressure lag. The oscillations occurred regardless of engine operating conditions and were most pronounced at peak pressures, they were eliminated by the use of the 0.032- and 0.025-in. diameter passages. It thus appears that for the length of passage used ($1\frac{1}{2}$ in.) it is necessary to use less than 0.040-in. diameter passage to eliminate pressure oscillations and dampening. A pressure lag will be present regardless of the passage diameter selected, but for qualitative types of analyses the magnitude of this lag is insignificant. Either the 0.032- or 0.025-in. diameter passage, therefore, will suffice for qualitative analyses of pressure development during combustion.

In addition to improper clearance space and too large a passage diameter, signal distortion can result (1) from pressure leakage between indicator and adapter, (2) from burred passage edges, and (3) from deposits in the passage and clearance volume. The first two can be eliminated by reasonable precautions during assembly and the last by disassembly and cleaning when necessary.

Detecting Abnormal Combustion

The change in pressure development signaling autoignition of the end gas is easily detectable on the pressure-time trace. Autoignition usually occurs, timewise, at a point just past peak pressure. Fig. 2 shows a series of pressure development signals from the spark-plug pressure-indicator combination with engine conditions set to give the slightest indication of autoignition. This combustion condition is arbitrarily classified as "borderline autoignition." As would be expected, this is not usually audible. Fig. 3 shows the severity of autoignition resulting from advancing the spark timing several crankshaft degrees to "borderline knock" as it would be defined by currently used standards of audible knock rating.

Surface ignition is distinguished from normal combustion by its increased rate of pressure rise, increased peak pressure, and earlier peak pressure timing. Surface ignition noise may manifest itself with or without knock. In the latter case the noise is of a thudding type. Pressure-indicator signals of these two phenomena are shown in Fig. 4.

The spark-plug pressure-indicator in unmodified engines has yielded information on abnormal combustion which could not have been obtained in any other manner. It has also proved extremely useful in applications such as determination of peak pressure and rate of pressure rise during normal combustion.

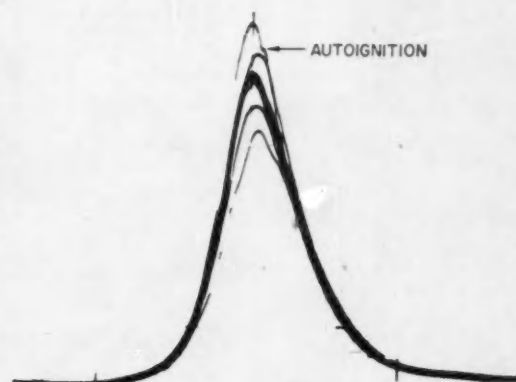


Fig. 2—Spark-plug pressure-indicator signals of borderline autoignition on indolene 30 gasoline at 3600 rpm.

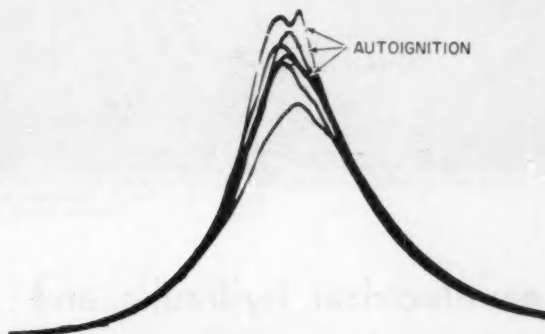


Fig. 3—Autoignition severity at borderline knock (audible method) on indolene 30 at 3600 rpm. Signal obtained from spark-plug pressure-indicator.

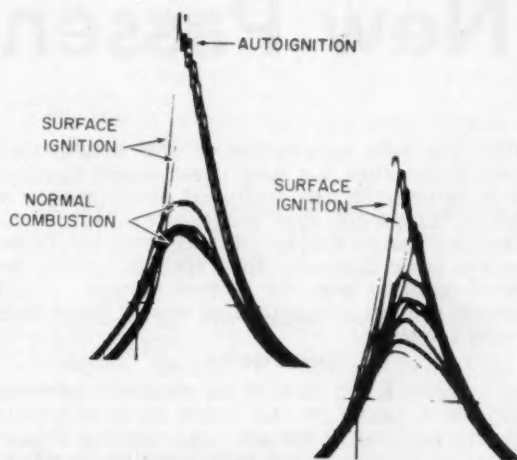


Fig. 4—Pressure development under conditions of surface ignition on indolene 30. (Left) with knock at 1600 rpm, (right) without knock at 3600 rpm.

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. . . on which this article is based, turn to page 5.

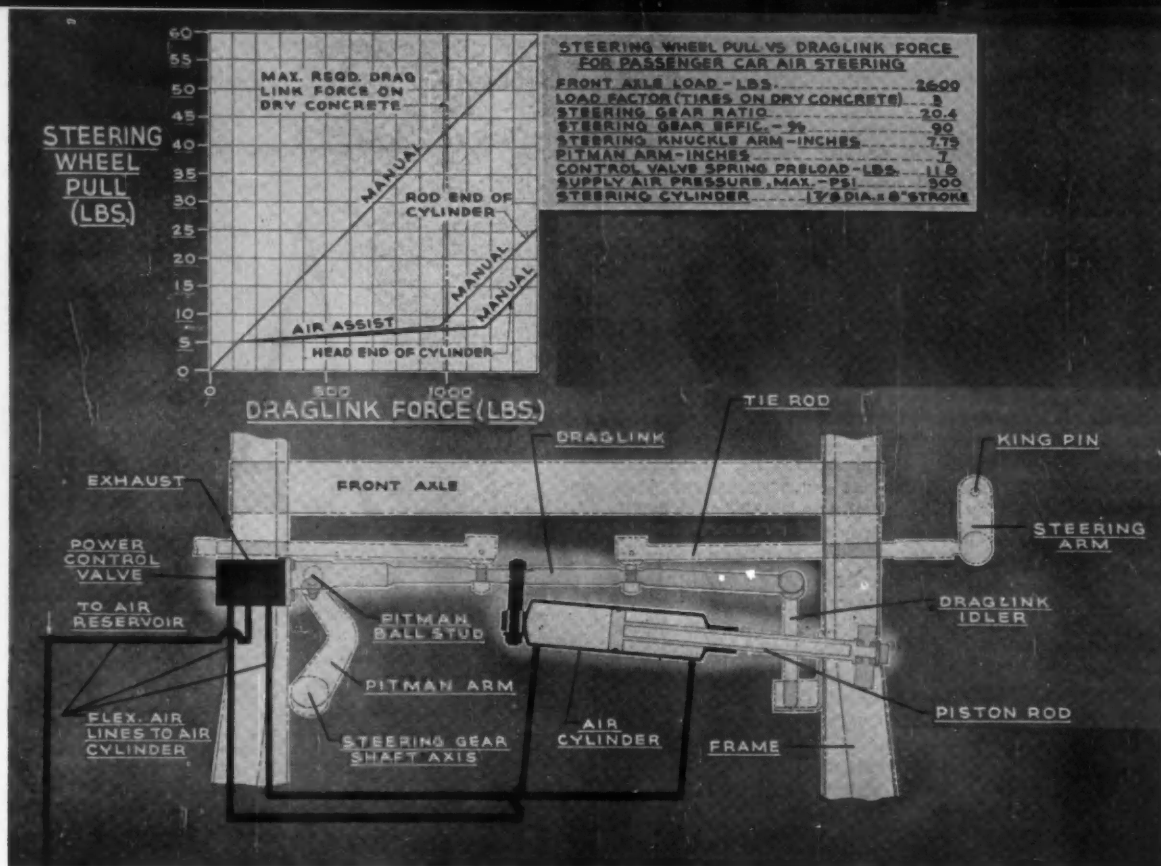


Fig. 1—Passenger car air steering system.

New electrical, hydraulic, and

pneumatic systems provide

New Passenger-Car Power

THREE separate approaches to the automobile's growing demands for new power-assist applications have brought new technical developments in electrical, hydraulic, and pneumatic aids. Many applications can be met by all three systems. Other areas are more favorable to a specific system because of qualities peculiar to that system. Here's a glimpse, present and future, of what's being done in power assists.

Power Steering

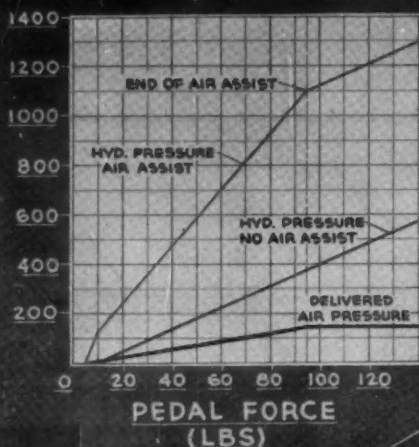
Fig. 1 shows a top view of an air power steering system for a passenger car based on a maximum system air pressure of 250 psi. The steering linkage shown is conventional, but modified slightly to accommodate mounting the air steering components, which consist of a power control valve, a double-acting cylinder, and flexible lines from the control valve to the air cylinder and supply reservoir.

The power control valve is mounted to the left end of the drag link. The air cylinder is attached to the drag link through a flexible member or ball joint to permit articulation. The right end of the piston rod is anchored to the frame so that it has no linear motion along its own axis. The cylinder moves with the drag link.

The power control valve is provided with a slight lost motion between the pitman arm ball stud and drag link. This permits opening and closing the pneumatic inlet and exhaust valves in the valve without moving the drag link when the pitman arm is turned slightly. With air in the system this action permits the flow of air to or from one or the other end of the air cylinder, as the case may be, and produces air assist when steering.

For example, when the pitman ball is moved slightly to the right (partial right turn)—before

HYDRAULIC PRESSURE (PSI)



Abridged from
SAE Detroit Section Papers

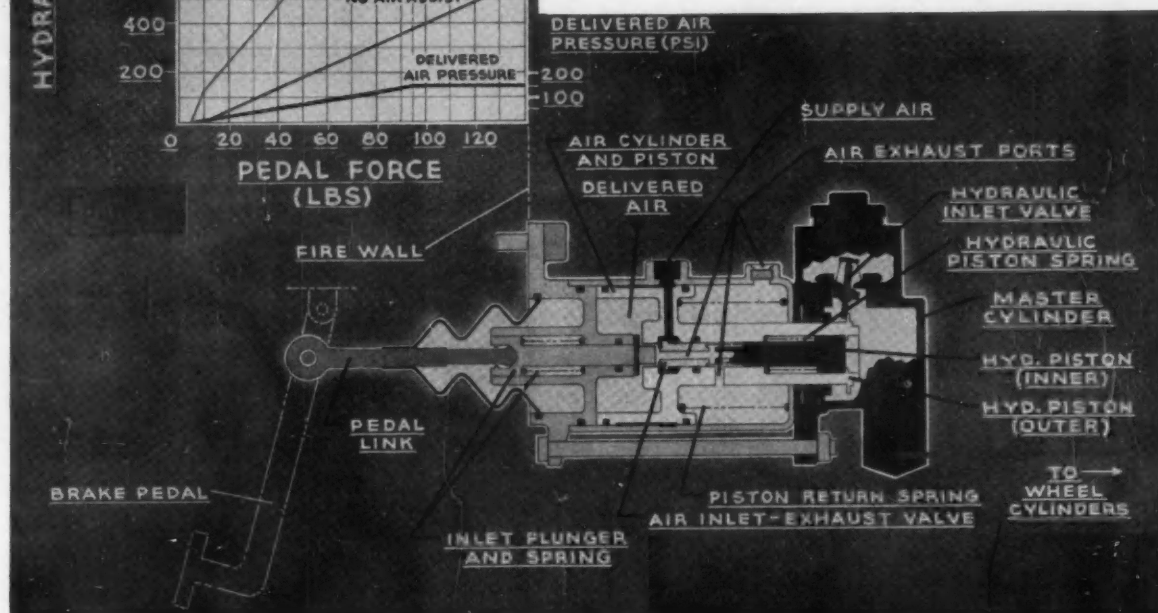


Fig. 2—Air-hydraulic brake actuator.

Assists

the lost motion or free travel is completely consumed and before any appreciable resistance from the wheels is felt at the steering wheel—one pneumatic inlet valve opens, admitting high pressure air to the right end of the cylinder which forces it and the drag link to the right until the inlet valve automatically closes.

The valves at this point are in lap position, that is, both the inlet and exhaust valves controlling the air to and from the right end of the cylinder are closed, entrapping just the right amount of air in the cylinder to prevent over or under steering. Pre-load springs in the power control unit give the desired steering wheel "feel".

In the event of loss of air, steering is accomplished as just described, with the following exception: In turning the wheel, when the free travel of the pitman arm is completely consumed, the pit-

THE INFORMATION IN THIS ARTICLE is based on the following papers which were presented before Detroit Section of SAE:

"Trends in Electrical Power Assists for Automated Automobiles" (Paper No. S21)

Vaughn H. Hardy, Delco Appliance Division, General Motors Corp.

"Automated Automobiles—Trends in Power Assists—Hydraulic Systems" (Paper No. S20)

P. C. Mortenson, Vickers Inc.

"Pneumatic Systems and Devices for Automobiles" (Paper No. S18)

Stephen Johnson, Jr., Bendix-Westinghouse Automotive Air Brake Co.

To Order Papers Nos. S21, S20, or S18 . . .
... on which this article is based,
turn to page 5.

Fig. 3—Pneumatic window lift.

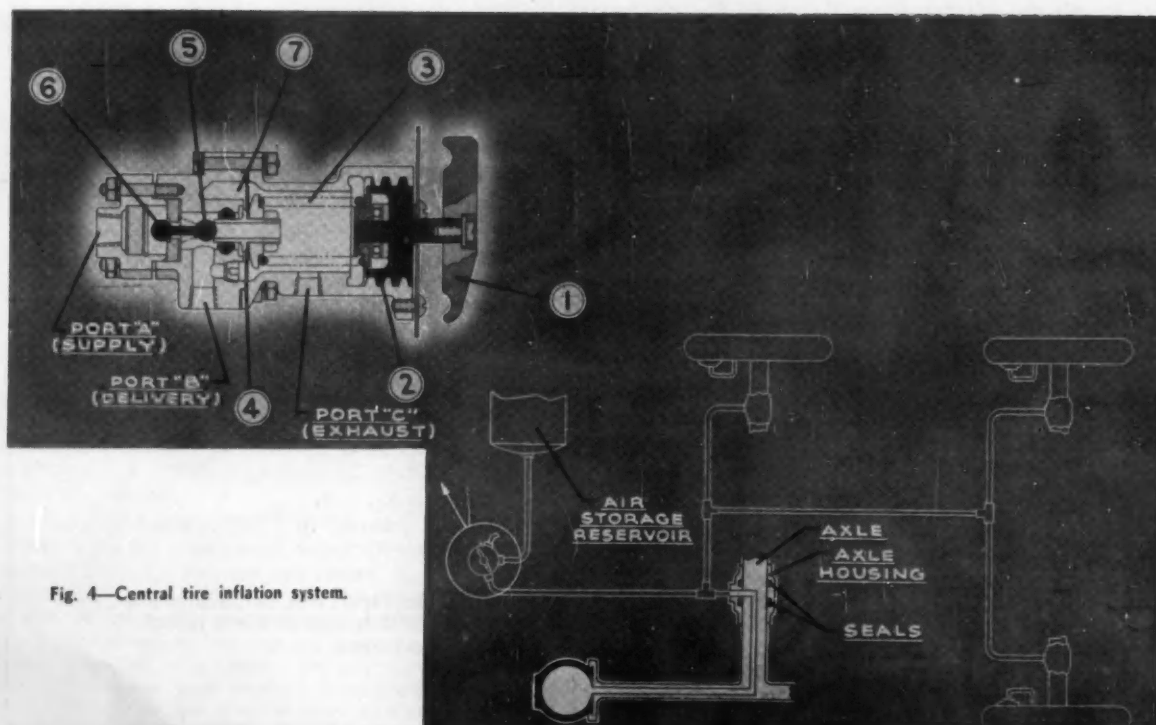
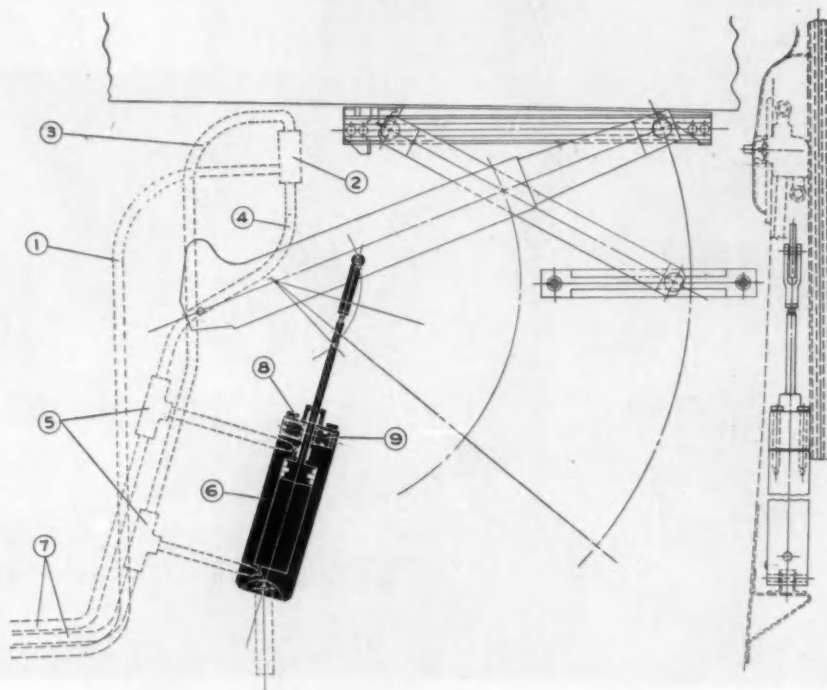


Fig. 4—Central tire inflation system.

man ball socket makes physical contact with the drag link, moving it and the wheels in the direction of turn. The steering wheel effort will increase considerably over the effort with air assist, because the system under these circumstances has reverted to pure mechanical steering.

The curves in Fig. 1 show the steering wheel effort versus drag link force, or the force necessary to overcome the resistance set up by the front wheels when turning. This force is directly proportional to the load on the front axle and is based on tires at rest on dry concrete.

An outgrowth of **hydraulic power steering** is a newly developed crankshaft-mounted pump which will provide the power for steering on several 1958 automobiles. The new arrangement eliminates two pulleys, a driving belt, and a mounting bracket from the front of the engine.

Pumps supplying the power for existing automotive hydraulic steering systems have a relief valve setting in the range of 1000 psi. With some steering developments that are now in progress, it appears that a requirement for 1500-2000 psi is not far away. Earthmoving and mobile materials-handling equipment are now using pressures considerably in excess of 2000 psi with notable success. With pressures of this magnitude available for automotive central hydraulic systems, the operating components can be reduced further in size and made more compact.

The future may bring some form of **electric power steering**. Envisioned here is not just an assist, but also a correction factor in steering. Yaw and side-wise drift would be integrated into the steering by a rate gyro and lateral accelerometer in conjunction with electric controls.

Power Braking

There appears to be a future possibility of straight air brakes being considered for passenger cars, but an earlier consideration will be **air-hydraulic power units** and the requirement will be a specific design, small in cube, light in weight, and economical in cost.

One promising design is shown in Fig. 2, the operation of which is as follows:

When pressure is applied to the brake pedal, the linkage and input plunger advances to close the air exhaust valve and open the inlet air valve. With supply air in the system, air is metered to the power cylinder causing the air piston with integral inlet valve seat to advance until it catches up with the air inlet valve, shutting off the flow of air to the cylinder. The advance of the integral air-and-hydraulic piston, of course, displaces hydraulic brake fluid to the wheel cylinders permitting a buildup of hydraulic pressure and consequently a deceleration of the vehicle.

To effect braking without air assist, the pedal and linkage must be advanced until the shoulder of the inlet plunger comes in physical contact with the air piston. Any further movement of the pedal then causes movement of the integral air-and-hydraulic piston, displacing the hydraulic fluid. This builds up pressure, and results in deceleration of the vehicle.

When the brake pedal is released, the inlet-plunger spring assists the release. The piston spring returns the air piston to the position shown,

causing the hydraulic pressure to drop accordingly. The air that is entrapped in the cylinder is vented through the exhaust ports in the piston and cylinder to atmosphere.

Referring to the performance curves shown in Fig. 2, note the quick rise of the lower end of the hydraulic pressure curve with air assist. This produces light braking forces with a minimum of pedal effort and is accomplished in the following manner:

Upon moving the pedal to open the air inlet valve, until the resulting hydraulic pressure is sufficient to collapse the hydraulic piston spring and permit physical contact of the inner hydraulic piston with the air inlet valve, the pedal reaction is a function of only the inlet plunger spring and the air pressure on a small portion of the inlet plunger. Beyond this hydraulic pressure, the pedal force is a function of the existing hydraulic pressure on the projected area of the inner hydraulic piston, plus the original forces.

Windshield Wipers

One major use at present for **electric actuators** is in the **windshield wiper**. The constant-speed shunt motor provides an advantage for this operation. It has ample reserve in power and has armature inertia to overcome intermittent loads. A simple harmonic motion gives smooth reversals at the ends of the stroke.

One problem with electric windshield wipers is the requirement that an additional movement be added to the stroke to park the blades against the rail in the off position. Another problem is that at least two speeds are required.

There are two methods now in use to park the blades on the rail. One is to reverse the motor to park and in so doing have cams which automatically lengthen the driving arms to get the added movement. The reversing motor, however, adds more complicated wiring to the switch and extra connections to the motor. The other method is a mechanical latch which stops the arm at the end of the stroke and then sets in operation a cam to lengthen the arm. This method substitutes mechanical parts for electrical wiring and switching. Neither of these systems, from an economic standpoint, is an entirely satisfactory answer to the problem and undoubtedly in the future more simplified designs will replace them.

To obtain two or more speeds with a shunt motor, the field is weakened for the high speeds. This automatically reduces the starting torque to too low a value. Additional starting torque is achieved by the addition of a series field.

Air windshield wipers have been used on trucks and buses for many years and certainly are practical for passenger cars. Air consumption, however, is a most important consideration.

The use of a **hydraulic windshield wiper drive** would be a by-product of a central hydraulic system. Such a drive would have the advantage of providing greater power under adverse operating conditions and would provide the desired speed control.

Suspension Systems

One recent development in the automotive industry is the hydro-pneumatic suspension system. This system can readily become a part of the over-

all vehicle central hydraulic system. In a hydro-pneumatic suspension system the conventional springs are replaced with telescoping chambers filled with hydraulic fluid and an inert gas. In addition to several vehicle handling and ride advantages claimed by chassis engineers, this suspension system permits automatic vehicle leveling by pumping an additional volume of oil into the telescoping suspension cylinders. With a suspension of this type, controlled principally by the flow of a fluid, any reasonable degree of ride softness is available to the suspension design engineer.

Other Potential Power Assists

Air horns have been used for many years on trucks and buses and also are practical for passenger cars. Here again, strict attention must be paid to air consumption in the design.

Fig. 3 shows a diagram of the components involved in a **pneumatic window lift**.

Reservoir air pressure is supplied to the control valve (2) through a plastic air line (1). The control valve (2) is a simple "on-off" valve with three operating positions.

1. A "window closing" position in which air is delivered through line (3).
2. A "window opening" position in which air is delivered through line (4).
3. A neutral position in which both lines (3) and (4) are exhausted to atmosphere.

Air is delivered to the actuating cylinder (6) through double check valves (5). These check valves are necessary since the actuating cylinder can also receive air through lines (7) from a control valve operated by the vehicle driver.

The window lift linkage shown is typical. The actuating cylinder (6) is a simple double-acting cylinder with two additional features:

1. Orifice bleeds are used to control the rate at which the window is raised or lowered.
2. A spring-loaded friction lock (8) is provided to lock the window in a fixed position after the passengers have adjusted the window to the desired position. This friction lock is released by air pressure on piston (9) when the window lift is being operated.

Air-powered engine starters or cranking motors, have been produced for industrial type engines for over 20 yr. Within the last few years they have been used for starting truck engines. They may have possibilities for passenger-car use.

Air-inflated seat cushions could be used whether or not the car has an air system, unless there would be a desire to put an automatic or manual adjustment feature into the picture.

The day of a **tire inflation system**, which is built into the vehicle and provides a control within the

driver's reach to permit increasing or decreasing the air pressures in the tires, may not be far away.

Such tire inflation systems have been developed and tested on military vehicles. They were used to adjust tire pressures to suit the ground or road conditions, that is to obtain better traction. The piping diagram of one of these systems is shown in Figure 4.

An adjustable pressure regulating valve is used to receive air from the reservoir and transmit pressure to, or exhaust from, the tires to which the valve is connected by tubing through a sealing arrangement built into the axles.

Fig. 4 shows the regulating valve with air from the reservoir entering at port A and connections to the tires at port B. This regulating valve is of the graduated type in which air pressure force is balanced with spring force. The valve is provided with a rotating handle (1) which operates threaded member (2), thus increasing or decreasing the length of spring (3), consequently changing its force on diaphragm (4). When the dial is set to a pressure higher than that in the tires, exhaust valve (5) is closed and inlet valve (6) is open admitting air to the tires as well as to cavity (7). When the force created by the pressure in cavity (7) acting on diaphragm (4) is equal to the spring force, the valve reaches lap position in which both exhaust valve (5) and inlet valve (6) are closed, thus trapping pressure in the tires. When a decrease in pressure is dialed, the spring force is decreased and the air force moves the diaphragm up, opening the exhaust valve until a new lap position is reached.

The use of **hydraulic drives** for the generator, refrigerator compressor, and fan is particularly worthy of passenger-car consideration. In conventional belt driven installations each of these is driven in direct proportion to the engine speed. When the engine is idling, the fan, generator, and compressor are driven too slowly; and, when traveling on high-speed expressways, these components are driven at speeds considerably faster than required. The use of a hydraulic motor in conjunction with a central system will permit these units to be driven at a constant speed, independent of the engine speed, with a considerable reduction in horsepower loss. In addition, these components would not have to be designed to operate at excessively high speeds, as is the case with generators on present automobiles.

One of the complaints often heard from women concerning convertible tops is that they are too hard to clamp down at the windshield. Here **electric-powered header locks** are bound to appear in the future.

Some **electric steering control** method will be devised to steer automatically on the thruways. This will involve some type of servomechanism to control the steering and speed. One can also easily envision radar control of the car to prevent "tail gating" or following the next car too close. Traffic controls can conceivably be operated by short wave radio. These are visionary applications but certainly not beyond the realm of possibility.

Zeder Foresees Solar-Powered Car

Based on talk by

James C. Zeder

vice-president, engineering—special advisor to president, Chrysler Corp.

SAE PAST-PRESIDENT JAMES C. ZEDER

sketched a "Portrait of Tomorrow's Engineer" in his address to a meeting of SAE's Detroit Section on the occasion of the dedication of the new Automotive Engineering and Aeronautical Engineering Laboratories at the University of Michigan.

On the same day, the University of Michigan conferred upon Zeder an honorary degree of Doctor of Engineering, citing him for "his ability to deal with administrative problems and to organize more effective methods of industrial production."

On this page are some of the predictions about tomorrow's engineers—and tomorrow's engineering made by Zeder in his U. of M. talk.

IT is possible that, at sometime before the end of the century the automotive industry will be producing cars driven by solar power.

We know how to get electrical energy from sunlight by means of silicon converters. If we continue to increase the efficiency of these converters—and if we are able to develop small efficient storage cells, a solar-powered car might be possible.

If such a car were developed, all the owner would have to do is to drive into a service station periodically and exchange a rundown energy cell for one freshly charged by the sun.

★ ★ ★

There will be a big challenge to the engineer of tomorrow—and the portrait of tomorrow's engineer will be formed by mankind's needs, hopes and dreams.

The great progress of the last half century has been, in a large measure, the result of the resourcefulness, the perseverance, the ingenuity, the technical skill, the creative imagination of the engineer. And it seems clear to me that these qualities will be of increasing importance as the world meets the challenges of the next half century.

Electronic brains are no substitute for human brains. One of the crucial needs of the future will

be brainpower. The mounting needs of a growing population present a real challenge, but with an almost infinite potential supply of raw materials and energy, we can satisfy those vast needs—if we have enough brains. In fact, the extent to which we realize that potential is probably a function of the amount of scientific brainpower we can put to work.

★ ★ ★

Production of materials and the output of food in the future may very well fall short of meeting our needs unless we have an adequate supply of technical brainpower.

The mounting demand for technical skills and the growing complexity of technology will increase the needs for and the usefulness of engineering specialists. In our profession, as in medicine, there seem to be fewer and fewer "general practitioners" and more specialists. It seems pretty certain that this trend will continue in the years ahead. Tomorrow, as today, engineering will be widely diversified. The areas of endeavor within the profession itself will multiply, and more and more the engineer's abilities will be required in management, government, and education.

★ ★ ★

The engineer will have to be an intelligent, liberally-educated man with the ability to share his knowledge and competence with others.

Technology has virtually wiped out isolation, and the technology of the future will promote even closer economic and social ties among the races and peoples and countries of the world. The engineer of tomorrow will have to relate his activities not only to his employers, his community, and his countrymen, but to the comfort, health, and enjoyment of peoples everywhere.

★ ★ ★

"The need today," wrote Mortimer Cooley, "is for men of broad view . . . men who are without narrowness, stupidity, and selfishness."

Broadened knowledge will provide the engineer of tomorrow with the ability to adapt to rapid change. New powers, processes, and products will be developed with the speed of a space rocket . . . at an always accelerating rate. Change alone does not mean progress; the speed of progress is determined by how quickly man is able to adjust to his ever-changing environment. In a fast-changing technological future, it will be the job of the engineer and of the scientist to lead the way in meeting the challenges of new conditions and innovations.

In most scientific development there is danger as well as opportunity. And some of the "buffeting waves" of the future will be frightening and be-

wildering—like today's atomic and hydrogen bombs. But man has always lived with powers that could easily destroy him, and he has reached higher levels of human achievement and knowledge by overcoming them.

★ ★ ★

Engineers are scientists of application. It is they who put to beneficial uses the knowledge and techniques developed by others. With the engineer's help, future technology can give man the opportunities to broaden the dimensions and the grace of his life—to lift himself out of poverty and misery—to

realize his dignity as a human being—and to add to his spiritual stature.

In the future the engineer will possess essentially the same qualities he has to have today. His world will be different—it will be more complex, faster moving, faster changing. But his purpose will be the same: to apply all the resources of science and nature to the solution of human problems.

Tomorrow's engineer will simply be a man living in a bigger world—and as a result he will be a man with more knowledge, broader horizons, many more problems, and a greater responsibility for putting the forces of technology to work for human progress.

High-Strength Weldments . . .

. . . have definite role to play in aircraft and missile structures. Fabricating method keeps tooling costs low and flexibility high.

Based on paper by

B. R. Alsobrook Rhor Aircraft Corp.

HIGH-strength, steel weldments permit greater flexibility of design and fabrication than forgings or castings. Changes can be incorporated into production with minimum cost and flow time. And the finished welded structure, comparable to a machined forging in strength and weight, is often lower in cost.

Steel weldments in production are heat-treated to 180,000–200,000 psi ultimate tensile strength, using AMS 6434 steel and joining with AISI stainless rod. Radiographic standards and production weld qual-

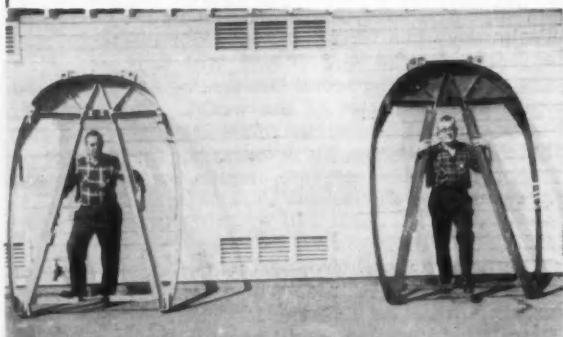
ity, as now established, indicate present design allowables of 120,000-psi ultimate and 80,000-psi limit loading for the weldments can be increased by 19,000–40,000 psi. And what is being learned about design and fabrication techniques with low-alloy, high-strength steels can be applied to a very large degree to stainless steels and super alloys.

Rohr is making structures of all-sheet-metal components, all-forged components, and combinations thereof. Illustrated on this page is a fuselage main bulkhead, the largest and most complex weldment currently in production.

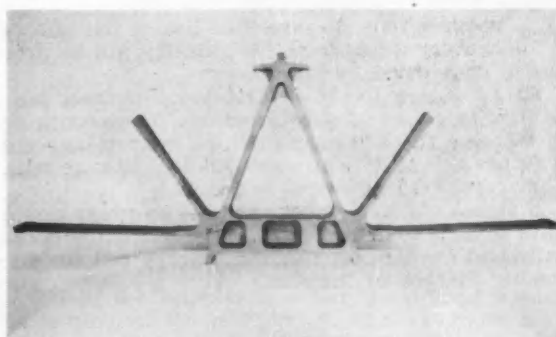
To Order Paper No. 211 . . .

. . . on which this article is based, turn to page 5.

Fuselage Main Bulkhead Weldment

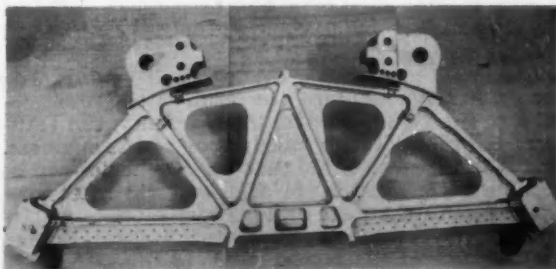


Above: This fuselage main bulkhead is fabricated in three basic sections, the crown and two Vee struts, which are joined by unheat-treated welds.



Upper right: One of the two spiders required for the assembly, formerly made from eight details joined by eight butt-tension welds, now flame-cut from one forged billet and machined. This saves weight due to absence of thickened areas for welding, and direct labor-hours in welding and inspection. New design will incorporate both halves of spider in one piece. Web, formerly sandwiched between the two spiders will be fillet-welded in place.

Lower right: Spider assembly with center web and main load-carrying fittings.





SAE LOOKS OVERSEAS

by WILLIAM LITTLEWOOD

When SAE's Overseas Information Committee learned that SAE Past-President Littlewood was going to England last Fall for the SBAC Exposition at Farnborough and for the Anglo-American Aeronautical Conference at Folkstone, it asked him to record—for fellow members of SAE—his personal impressions of both events. He does so in this interesting article. (Littlewood is vice-president, Equipment and Research, American Airlines, Inc.)

The intent of these comments is merely to express a few general and philosophical remarks as accented by last Fall's Sixth Royal Aeronautical Society-Institute of Aeronautical Sciences Anglo-American Aeronautical Conference and by the Society of British Aircraft Constructors Exposition at Farnborough.

BS NOW
MEANS
"BEFORE
SPUTNIK"

September, 1957, was One-twelfth BS—that is, one month Before Sputnik, and One-sixth BP, or two months Before Poochnik, (at this writing, I cannot say how many months before Moonik!). Consequently, although the Farnborough Exposition had an area devoted to obviously dummy missiles of small size and limited military significance . . . and although the Folkestone Conference dealt lightly with supersonic and hyperballistic problems and with nuclear propulsion, there was no reference whatsoever to satellites except as small countries which orbit about larger and more significant political entities.

Understandably frequent and sometimes slightly embittered reference was made to the "White Paper" which had cast a pall on much British aeronautical activity by forthright and drastic cancelation or curtailment of military manned-aircraft projects of all types. The least protest came, of course, from those organizations fortunate enough to be already applying their efforts largely to missile projects or to civil aircraft and related ventures.

CONTRASTS
IN
REACTIONS

The British seem to accept these bludgeonings of fate with better grace (or stoicism) than do their American counterparts. While many a "White Paper" joke was told with a rather wry grimace, and, restrained references

(Continued on next page)

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C. C. A. Rosen, chairman

SAE LOOKS OVERSEAS

were made thereto in toast and speech, one sensed a grim determination to make the best of a bad situation and to "get on with the job"—even though it be somewhat altered in nature. I am sure the British reaction to subsequent Satellite events has been restrained and rational in almost startling contrast to the hysterical reversal of plans and trend which has beset our programs and leadership in the United States. America has much to learn from the stability and logic of British thought and reason under real or imagined stress.

FUTURE FOR FARNBOR- OUGH??

One wonders whether the Farnborough air show can sensibly carry on for the future. Missile exhibits seem of little interest to the public. The models are obviously dummies. Demonstration firings of any great scope can hardly be made. All really advanced designs and details are highly classified and under wraps. The human element is entirely missing.

There was little this year and must be much less for the future of new manned military aircraft exhibits, or of the accessories and equipment that go into them.

Even in the civil aircraft field there was hardly anything that has not been previously shown and demonstrated, except for a few unnoticed modifications. There was much emphasis on the VTOL-STOL types - but little that was new or unannounced. Civil aircraft developments may provide the material for future shows - but will there be enough to justify an elaborate and expensive exhibit like this?

FLYING FEATS THRILL

The flying exhibitions, singly and in groups, were the best I have ever seen, conducted with marvelous precision and almost foolhardy daring. They were thrilling but worrisome.

The British love an outing, a picnic, a show, an exhibition - even more than we do. And Farnborough has been a grand "all-of-these." But this year there seemed little on which to build the elaborate exposition structure...and there may well be less for the future.

As to the Sixth Anglo-American Aeronautical Conference, we loved Folkestone and the cordial hospitality of our genial hosts (and charming hostesses!). I cannot accept Captain Pritchard's indictment of "A Mediocre Conference" as he reviewed it in The Aeroplane of September 20th. True, there were no intimate revelations in violation of the absurdly restrictive security rules. Nor were there any world-shaking technical or philosophical disclosures. But there were many delightful and stimulating subconferences, covering with great frankness a wide range of subjects, aeronautical and otherwise.

SAE LOOKS OVERSEAS

NO SLEEP AT MEETINGS

The chairs of the conference room were of two types - both designed to help overcome the devastating sleepiness of the post-luncheon sitting. One variety was so hard and rigidly upright as to forbid the surreptitious snooze - on penalty of a painful tumble. It further induced a mild paralysis of the derriere - after which all pain ceased and the sitter's attention became riveted on the lecturer and his dissertation. The other type was more unique in providing a restricted seat width with limiting sides which, while providing some arresting action against an unintentional Dutch roll, squeezed "the spread" into the aforementioned condition of partial paralysis, again preventing unwitting somnolence. These devices worked perfectly, and the audiences were unfailingly attentive.

There were many excellent papers, and in my opinion it was a good Conference. If there was not as much frank dealing with technical matters as might be desired under a more enlightened, mutual security arrangement, there was nevertheless a fine interchange of mutual respect and good will.

The papers were well presented, and each discussor, as usual and almost without exception, took the opportunity to disregard the speaker and his presentation and to express his own ideas - and at considerable length!

The efforts to educate the bar boys to convert a "gin and French" to a Martini, and to add a bit of ice to a warm Scotch and soda, continued unabated throughout the Conference at odd and informal moments. The success of these ventures fell far short of that achieved in mutual examination and concordance in technical matters.

BRITISH RESEARCH ALERT

But, seriously, British aeronautical research is on its toes, and one never ceases to admire how much it accomplishes with so little, relatively, to do with. One is much impressed by the examples of aggressive enterprise in the development and production of civil aeronautic ventures. One cannot escape the thought that much of American inventiveness, ingenuity, and individual enterprise have fled these shores and have emerged abroad - in Britain and elsewhere. And, one has only to appreciate the relative stringency and drive to understand the necessities and incentives which make this unfortunately and increasingly true.

We Americans were very proud of our representatives on the Conference program, and particularly of Clark Millikan as he presented the Wilbur Wright Lecture in London following the Folkestone meetings. And, our British cousins may well be proud of their lecturers and their presentations - hampered as we all were by the strictures on discussion of matters, known only to our international competitors!

Jet-Deflection Devices . . .

. . . provide directional control or lift for jet-operated VTOL and STOL aircraft. NACA has tested devices applied to both conventional and unconventional exhaust nozzles.

Based on paper by

Uwe H. von Glahn and John H. Povolny

Lewis Flight-Propulsion Laboratory, NACA

LIFT-augmentation or directional control can be provided on jet-operated VTOL and STOL aircraft by a variety of jet-deflection devices applied to the exhaust nozzle. In general, devices that turn or deflect the entire jet rather than a portion thereof are more efficient.

For conventional round nozzles, the swiveled nozzle, swiveled tailpipe, external flap, and swiveled shroud are most suitable for either directional control or lift augmentation (as shown in Fig. 1). Other deflection devices for conventional nozzles, such as the movable plug, internal flap, cylindrical thrust reverser, swiveled primary with fixed shroud, and

90-deg side-bleed nozzle, are limited in application to jet directional control or aircraft trim. The reason is that the loss in axial thrust for a given deflection force is prohibitive, or the maximum deflected force obtainable is limited.

Among unconventional configurations, the Coanda nozzle, which deflects the jet over a surface attached to the nozzle, as shown in Fig. 2, has proved effective. The Coanda nozzle can achieve 90-deg jet deflection and, for the rectangular nozzle studied, achieve a lift (deflected force)-to-jet thrust ratio of 83% for this deflection angle.

Another novel configuration is the annular nozzle












	CONFIGURATION	$(F_d/F_j)_{\max}$	POSSIBLE APPLICATION
1	 SWIVELED NOZZLE	0.35	CONTROL OR LIFT AUGMENTATION
2	 MOVABLE PLUG	.10	CONTROL OR TRIM
3	 SWIVELED TAILPIPE	~1.00	CONTROL OR LIFT
4	 EXTERNAL FLAP	.40	CONTROL OR LIFT AUGMENTATION
5	 SWIVELED SHROUD (HI DIA. RATIO)	>.30	CONTROL OR LIFT AUGMENTATION
6	 INTERNAL FLAP (LOW ANGLE)	.20	CONTROL OR TRIM
7	 SWIVELED SHROUD (LOW DIA. RATIO)	.35	CONTROL OR LIFT AUGMENTATION
8	 CYLINDRICAL THRUST REVERSER	.20	CONTROL OR TRIM
9	 INTERNAL FLAP (HI ANGLE)	.17	CONTROL
10	 SWIVELED PRIMARY, FIXED SHROUD	.16	CONTROL
11	 90° SIDE BLEED NOZZLE	~1.00	CONTROL

Fig. 1—Deflection devices in order of decreasing efficiency (least axial thrust loss for given deflected force). F_d = Deflected (side, pitch, or lift) force. F_j = Initial jet thrust without deflection device. $(F_d/F_j)_{\max}$ = Maximum deflected-thrust ratio attainable.

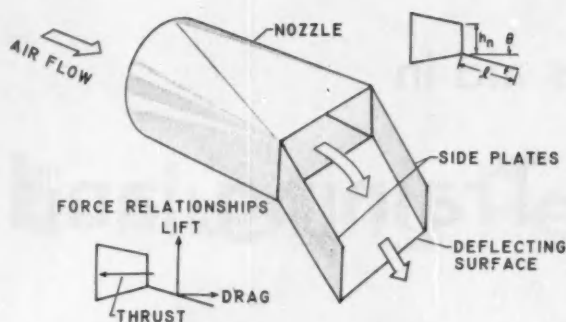


Fig. 2—Coanda nozzle using single flat plate for jet deflection.

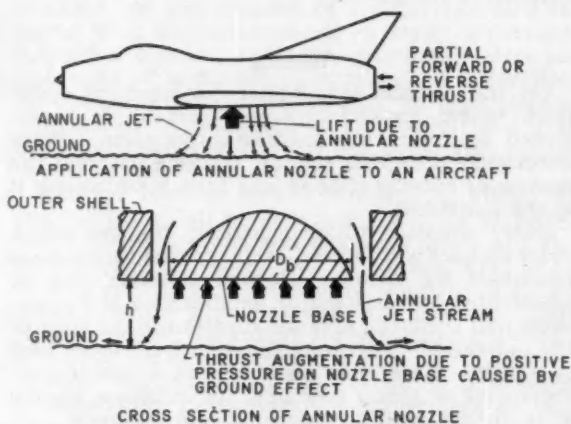


Fig. 3—Annular nozzle for jet-supported aircraft.

with jet directed perpendicularly to the ground (as shown in Fig. 3) to utilize a "ground effect" phenomenon. This device can achieve a large thrust augmentation (about 60%) near the ground.

Many of the jet-deflection devices applicable to conventional round nozzles for directional control or lift augmentation can be applied to existing aircraft. By augmenting the lift of an aircraft during take-off or landing, the required length of take-off or landing run can be reduced. Furthermore, by deflecting a portion of the jet thrust in flight for augmenting the normal lift of the wing, the altitude capability of the aircraft can be enhanced without serious loss in forward speed. At high altitude, jet directional controls can improve aircraft maneuverability over that available with conventional aerodynamic controls.

Best utilization of bizarre jet deflection devices (such as the Coanda nozzle and the annular nozzle) cannot be achieved by incorporating the device in existing aircraft configurations. Only by designing the aircraft with due consideration for the unique characteristics of the device will full value be obtained from it.

To Order Paper No. 219 . . .

. . . on which this article is based, turn to page 5.

Highway Construction

. . . can be speeded by radioactivity instrument that measures soil moisture content and density on-the-spot.

A feature of the
SAE Nuclear Energy Advisory Committee

BOTH automotive and construction engineers will find interest in a newly developed radioactivity instrument, which promises to speed highway construction. The *d/M* gage—as it is called—measures soil moisture content and density on-the-spot during soil compaction control tests. Thus, it will be possible, for the first time, for the highway construction engineer to determine when the optimum degree of soil compaction has been obtained—while the compaction equipment is still at the site of operation. Accurate and extensive studies of moisture-density data from such compaction control tests show that greater stability and more uniform wear in the completed highway result.

In contrast to the bulky equipment and time-consuming procedures required by conventional methods, a single nontechnical operator of the *d/M*-gage can obtain reliable moisture or density determinations in a simple 2-min operation.

Operational principle of the new system is based on the varying degree that radioactivity is "scattered" when placed in contact with masses of different moisture content or density. Measurement of the amount of scatter is equivalent to measurement of moisture content or density.

Application of this principle is made by inserting a moisture or a density probe, containing a radioactive source, into a soil mass and then measuring the resulting "scatter" with a radioactivity counting device (scaler). An operator obtains a total "scatter count" from the scaler and locates a corresponding figure on a calibration chart. Moisture content or density determinations of the soil being tested are read directly from the chart itself.

Accuracy of the system is within 2 lb per cu ft for density determinations over the range from 50–150 lb per cu ft. Moisture determinations are accurate to within 3/4 lb/cu ft from 0 to 100% moisture content.

An outstanding feature of the system is the substantial volume of soil analyzed in a single determination. The probes measure a spherical volume of soil with an average diameter of 14 in. Moisture or density measurements can be made at any soil depth from the top 12 in. to 60 ft below the surface.

The *d/M*-Gauge makes possible continuous studies of the same volume of soil over an extended period of time through the use of an access tube which is driven into the ground and left in place for future determinations. Either the moisture probe or density probe can be inserted into the access tube for measurements at any depth. Since the soil sample is chemically and physically unchanged by the testing process, such measurements provide an accurate basis for determining the effects of environmental or seasonal changes on a particular volume of soil.

Principles and techniques aid in Selecting, Training, and

Based on secretary's report by

R. H. Hamilton,

Chesapeake and Ohio Railway Co.

THE responsibility for selection, training, and performance evaluation of an individual lies directly with line supervision. In fact, personnel administration is a large part of the line supervisor's total responsibility. Certain successful principles and techniques are available, however, to aid the supervisor in discharging his personnel responsibilities in these three areas.

Selection

Selection is the process of picking an individual from among a group of candidates for a particular job. Ultimately this is the exercise of judgment, a judgment which becomes more valid as it is supported by ascertainable facts. To the professional in personnel, selection becomes therefore essentially a job of fact finding.

Successful selection will result in the picking of the individual best fitted to the job, not an individual who is merely fitted. Thus, the first requirement of successful selection is a definition of the job, in terms of authorities, responsibilities, required skills, and the like. It is against these established criteria that the facts concerning the individual are weighed, providing the basis for the exercise of informed judgment.

A number of fact-finding tools have been developed, each of which has a special purpose and use. Typical are the application blank, testing, performance on present job, and interviewing.

The application blank is a biographical history. On the principle that the odds are against change in an individual, his past history can be extrapolated to an estimate of future performance.

Testing can take many forms, but usually some form of intelligence test and behavior test is used. The intelligence tests provide a nearly objective measure of thinking ability. Measurements of the ability to get along with people have not yet achieved the same reliability, but are none-the-less useful.

Performance on the present job is essentially a performance evaluation.

Many interview techniques are available; those that fit best with the rest of the fact-finding process should be used.

Successful selection requires the use of all available data, and also that the data be accurate, for the exercise of judgment.

Training

On the premise that better management grows from better supervision, management is better served by improving existing supervision. Since improvement implies change, training becomes the process of causing change and then maintaining it in the individual.

Every situation which confronts the individual, every contact with others, each experience, contains potentials for growth. Growth, however, can be accelerated by selecting or emphasizing the situations and contacts, and the direction of change of the individual. The more common techniques used to achieve these ends are conference attendance, individual or group coaching, job rotation, special assignments, reading programs, and seminars.

Thus, training becomes the process of providing opportunities for and guiding individual growth, rather than a forcing endeavor. Its success depends, in no small measure, on the self-starting nature of the individual—upon his ability to use the opportunities profitably, to his own and management's benefit.

Performance Evaluation

Performance evaluation is the determination of a measure of an individual's success in relation to the requirements of his job. Since job requirements continually change, performance evaluation becomes a repetitive process, rather than a one-time affair. It must be a continuing program to produce worthwhile results.

The measures produced by performance evaluation can serve many purposes which may be broadly classified as follows:

1. To assist in effecting personnel transactions—
 - a. Promotions, transfers, and layoffs.
 - b. Allocating wage and salary increases.
2. To assist in supervisory development—
 - a. Development of individual training programs.
 - b. Identification of supervisors with potential.
 - c. Direct training device, by coaching or counseling.

Evaluating Personnel

In obtaining the required information to fulfill the purposes indicated in item 1, it is necessary to evaluate the performance of a supervisor as compared with the performance of other supervisors in similar positions or at the same level. Here one is interested in an overall appraisal of supervisory effectiveness. Useful techniques for this purpose are ranking supervisors from high to low on a basis of performance, or distributing them into several classifications of job excellence.

Another method, paired comparison, allows for the pairing of all possible combinations of supervisors within a group and making a series of judgments—one per each pair of supervisors. This method will serve to rank order a group of supervisors in terms of performance and has been found to be a reliable technique for obtaining a measure of overall job effectiveness.

When the purpose of the evaluation is to assist in supervisory development—improvement on current job performance and preparation for future assignments—measurement is in terms of the performance of the individual on the specific requirements of his job. Evaluation then becomes a process of making a series of judgments relative to the supervisors performance on the unique responsibilities of the job to determine those areas which:

1. Should be given attention to improve current job performance, and
2. Areas, for those individuals with advancement potential, which should be given attention to provide development experiences to qualify the man for advancement.

Of course, the key point in appraisals of this nature is the communication of the evaluation to the supervisor being appraised. This feedback serves as the basis for the mutual development of the individual training program.

Regardless of the purpose of evaluation or the method or technique used, certain criteria are important in the successful operation of an evaluation program. They consist of trained raters with an awareness of the purpose of the program and thorough understanding of the mechanics of the method used. Best results can be obtained by using a rating technique which provides sound information, is designed to accomplish the purpose of the program, and is acceptable to those charged with using it.

The logical steps in developing and establishing a performance evaluation program are:

1. Define the purpose of the program.
2. Develop a simple operating plan.
3. Train the people who will operate the plan, with emphasis on skills and attitudes.
4. Provide for the use of feedback for the continuing improvement and modification of the operating plan.

The operation of such a plan is the responsibility of line supervision, aided in the technical aspects by staff personnel. The probable success of the plan will vary directly with the extent to which this responsibility is accepted by the line organization.

To Order SP-320 . . .

. . . on which this article is based, turn to page 5.

THE EXPERTS who developed the information in this article were:

panel leader: **Fred Roberts,**
Chesapeake and Ohio Railway Co.

panel secretary: **R. H. Hamilton,**
Chesapeake and Ohio Railway Co.

panel members: **John Conway,** A. O. Smith Corp.

Ludwig Huttner,
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J. R. Niven, Boeing Airplane Co.

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Future Aircraft Electrical

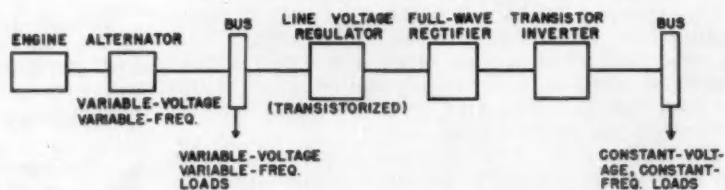
Constant-speed drives for aircraft generators are the best now, but one of these systems may replace them in the future.

Based on paper by

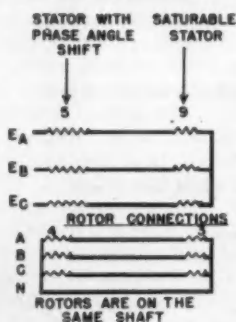
Karl Martinez

Boeing Airplane Co.

TRANSISTORIZED ALTERNATING CURRENT system could supply over 90% of the load with a variable frequency and voltage alternator. The remaining load would be satisfied by refining the voltage to a constant value with a transistorized switching voltage regulator. The current would then be rectified and inverted by a static inverter.



STATOR CONNECTORS



NOTES

TO ESTABLISH CONNECTIONS AND ALL POLARITIES.

- (A) IF NO PHASE ANGLE SHIFT, NO SATURATION - THEN INDUCED ROTOR VOLTAGES IN EACH ROTOR PHASE ARE RESPECTIVELY EQUAL AT ANY SPECIFIED SLIP. HENCE NO ROTOR CURRENT WILL FLOW AT ANY SLIP. $E_3 = E_4$
- (B) IF NO PHASE ANGLE SHIFT BUT (9) IS SATURATED $E_4 > E_3$. $I_4 = -I_3$ IN ANY ROTOR PHASE
- (C) STATOR (5) IS ADVANCED IN PHASE ANGLE (θ_5) MECHANICALLY, WHICH WILL INDUCE A VOLTAGE SOONER IN ROTOR(4).

- (D) OUTPUT AS A GENERATOR WILL OCCUR IF $E_4 I_4 \cos \theta_4$ IS POSITIVE ($E_4 \theta E_3$ ARE INDUCED VOLTAGES PRODUCED BY CUTTING STATOR FLUX)
- (E) FOR COMPARISON PURPOSES, IF THERE IS 5% SLIP AND ROTOR TERMINALS ARE SHORTED, FULL LOAD ROTOR CURRENT WILL FLOW. THIS IS ASSUMED TO BE THE THERMAL LIMIT OF THE ROTORS AS STANDARD INDUCTION GENERATORS.

SWEDISH system, constructed by Rotax Ltd., England, has two wound-rotor induction generators mounted on the same shaft. The two rotors are connected in parallel. The two stators are connected in series and supply electrical power for the airplane. Mechanically shifting one stator with respect to the other produced a phase angle shift between the two magnetic fields. One stator can be variably saturated. A small permanent-magnet generator on the shaft supplies power, through its rectified output for: Constant frequency and voltage references; d-c control; and one generator stator and magnetic amplifier saturation.

Correct operation at or near full load results when slip is low by producing saturation in one stator. When slip is high, little or no saturation is used, but essentially maximum phase shift is necessary. Better than 90% efficiencies are reported for 12% slip above synchronous speed between half and 120% of full load.

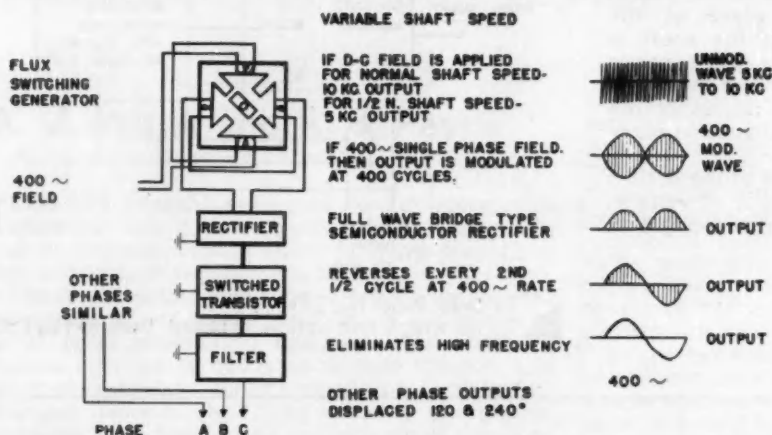
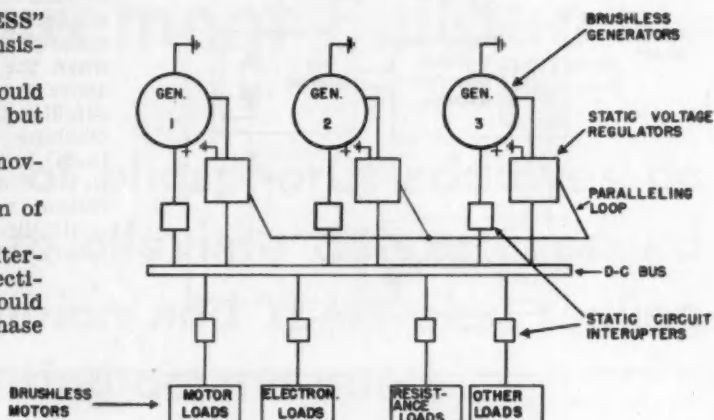
Systems Predicted

TRANSISTORIZED "BRUSHLESS" D-C system waits on power transistors and rectifiers.

The weight of the system should be equal to a 400-cps system, but would be:

- More reliable due to fewer moving parts.
- Simpler in parallel operation of generators.

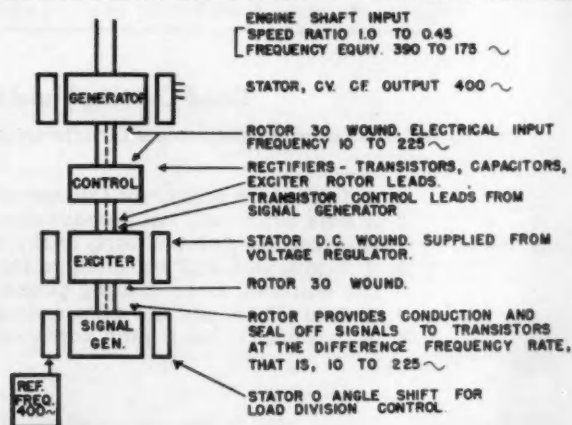
The generator would be an alternator feeding power to silicon rectifiers. The "brushless" motors would be static inverters with polyphase induction motors.



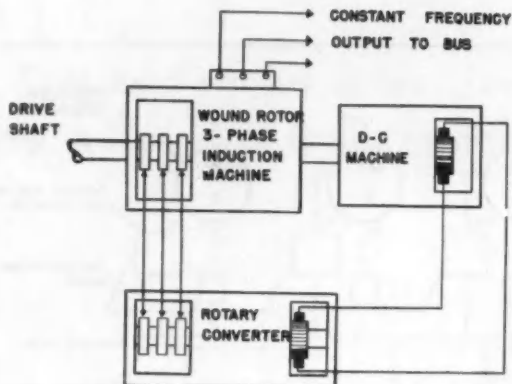
MODULATING the field of an alternator could produce constant-frequency output and avoid a constant-speed drive.

HOARD generator produces constant frequency and voltage without a constant-speed input.

Advantages of the system are: Good efficiency during 95% of an airplane's mission; no brushes, commutator, or slip rings are used; and control of frequency and load is electrical and instantaneous. High-power transistors are needed to build this system in the capacities needed.



(Continued on next page)

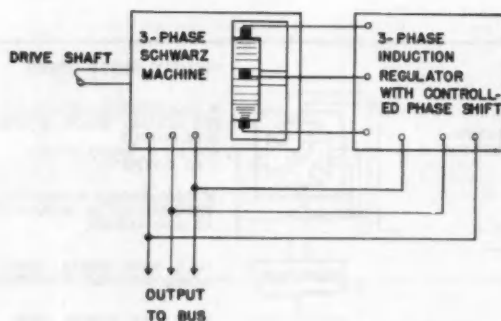


IN THE KRAMER constant-horsepower system, the main conversion of mechanical to electrical energy takes place in the induction machine. However, when the drive shaft is turning either below or above synchronous speed, electric power must be supplied to or removed from the rotor of the main machine. The amount of rotor power is proportional to slip. This rotor power is supplied by or to the d-c machine through the rotary converter. Output voltage and frequency are regulated by controlling the fields of the d-c machine and the rotary converter.

USING A SCHWARZ MACHINE will give sparkless a-c commutation due to its winding arrangement.

Main power conversion takes place in the Schwarz machine. However, when the shaft is turning above or below synchronous speed, power proportional to slip flows through the induction regulator. Control is exercised by adjusting the voltage ratio and phase shift of the induction regulator.

Controls must still be investigated to see if they are adequate for independent control of voltage, frequency, and load division when using the system as a primary power source.



To Order Paper No. 229 . . .

. . . on which this article is based, turn to page 5.

Good Cutting Fluid Meets 5 Requirements

■ The five most desirable characteristics of a cutting fluid, in order of priority, are:

1. A fluid which is safe for the operator's use.
2. A fluid which will not damage capital equipment by causing heavy oxidation on precision-finished parts of the machine.
3. A fluid which will not damage the workpiece by either eroding or etching the material, or by causing permanent stains.
4. A fluid which will not turn rancid and create obnoxious odors.
5. A fluid which has a high potential for removing heat from the workpiece.

A. E. Crom

Trialkyl Phosphines Reduce Octane-Requirement Buildup

New class of phosphorus additives go long way to alleviate deposit-induced surface-ignition and spark-plug fouling without raising octane need.

Based on paper by

A. V. Mrstik and R. B. Payne

Sinclair Research Laboratories, Inc.

TRIALKYL phosphines—a new class of phosphorus additives—can go a long way toward eliminating deposit-induced surface-ignition, spark-plug fouling, and octane-requirement buildup.

These particular additives actually *reduce* octane-requirement buildup instead of increasing it, as do other phosphorus additives. Yet they are equally effective in reducing surface ignition and spark-plug fouling, today's spawn of combustion-chamber deposits. And, like all other phosphorus additives, they don't make the cure worse than the disease, as is the case when surface-ignition is alleviated by blending fuels for low aromatic content, low end point and low tel content. (The fuel-blend solution to the problem of deposit-induced surface-ignition is not compatible with future needs. High aromatic content and high tel content are likely to be required by refineries to produce the high octanes necessary to prevent knock.)

All phosphorus compounds used were shown to be consistently effective in tests which compared the effects of a variety of additives in reducing surface ignition. With comparisons developed in terms of percentage reduction in ping-count effected by each additive, 0.3 theory of phosphorus reduced surface ignition by 50-75%, depending on the organic configuration of the molecule.

Also, among additives tested for their effect on spark-plug fouling, phosphorus-containing additives were the only materials studied which improved spark-plug performance.

But when it came to reducing knock, only tri-n-butyl phosphine and triethyl phosphine, both members of the new trialkyl phosphine family of phosphorus compounds, had a beneficial effect in reducing octane-requirement buildup. Other phosphorus compounds and all nonphosphorus compounds increased octane-requirement buildup.

Both tri-n-butyl phosphine and triethyl phosphine were also explored thoroughly in various multicylinder proof tests and in fleet tests. Typical results of fleet tests—which consisted primarily of suburban driving—are shown in Table 1.

In another evaluation of these two trialkyl phosphines, components for two brand new 1956 automobile engines were hand-selected at the factory to be as nearly identical as possible in all respects. The engines were then placed in identical cars. One car was placed on a premium gasoline without

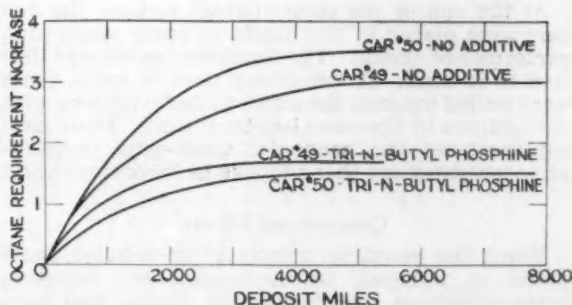


Fig. 1—Effect of tri-n-butyl phosphine on octane-requirement increase. (Based on road tests with clean engine.)

Table 1—Typical Fleet Test Results—Trialkyl Phosphine Additives
(Suburban-type driving)

	1954 Car A ^a 60% catalytic reformate, 40% fluid gasoline	1955 Car B	1956 Car C	1956 Car A
Base Fuel	— — Commercial	premium	gasoline	— — — —
Tel, cc per gal	3.0	— — — —	1.5	— — — —
Additive	Tri-n-butyl phosphine	Tri-n-butyl phosphine	Triethyl phosphine	Tri-n-butyl phosphine
Additive Concentration, theories of phosphorus	0.3	0.3	0.3	0.3
Test Results:	Without Additive	With Additive	Without Additive	With Additive
Equilibrium Octane Requirements:				
Primary Reference Fuels	97	97	95	93.5
Commercial Reference Fuels	100.5	98	—	—
Equilibrium Preignition Requirements:				
Primary Reference Fuels	95	91	81	79.5
Commercial Reference Fuels	100.5	95.5	—	—

^a Special 9.0/1 compression ratio heads.

deposit modifier additives; the other on the same gasoline with 0.3 theory of tri-n-butyl phosphine added.

The cars were driven within sight of each other over an 800-mile course, which involved city, open road, and suburban type driving. Primary reference-fuel spark-knock requirements and commercial reference-fuel surface-ignition requirements were taken at 24-hr intervals. After six circuits (approximately 5000 miles) each car had achieved equilibrium with respect to octane requirement and surface-ignition. At that point, deposits were removed and the fuels were switched in the two cars and the procedure repeated. The results obtained are detailed in Table 2.

Fig. 1 shows that the additive reduced the octane requirement of each car by about 1.5 octane numbers. The octane required to prevent surface ignition of each automobile was lowered by about two octane numbers. These results are typical of the performance obtained with the additive.

At the end of the cross-country testing, the two cars were placed in city traffic to study spark-plug performance effects. The maximum speed was limited to 35 mph. It was found that 16 spark plugs were fouled without the additive and only four with the additive in the same length of time. These data substantiated the beneficial spark-plug performance indicated for this additive in laboratory tests.

Concentrated Effects

When the beneficial effects of tri-n-butyl phosphine in reducing octane-requirement increase, surface-ignition, and spark-plug fouling had been fully confirmed, considerable work was done to establish the optimum concentration of the additive.

The lowest octane-requirement buildup was obtained with about 0.6 theory concentration. At the 1.2 theory concentration, the octane-requirement buildup was greater than 0.6 theory, and some tendency toward piston ring varnish was noted. Spark-plug fouling is essentially eliminated with 0.3 theory concentration. Moreover, surface ignition continues to be reduced with increasing additive concentration. Consequently, the optimum additive concentration is in the 0.3 to 0.6 theory range, depending primarily on what concentration is required to reduce surface ignition of a particular gasoline blend to an acceptable limit.

Effect on Gasoline Quality

The test work reported indicates that trialkyl phosphines as a class satisfy the requirements with respect to spark-plug fouling, surface-ignition, and octane-requirement buildup.

Further tests indicate that trialkyl phosphines are completely soluble in gasoline, are not extracted by water, and do not make the gasoline corrosive. The materials make a slight improvement in gasoline stability. They lower the Motor Method octanes somewhat, but have substantially no effect on Research octane ratings.

The reduction in Motor Method octanes is of no consequence, because substantially no reduction in road octane ratings is noted with the additive.

Durability tests have shown the materials to be satisfactory with regard to engine wear and valve durability.

All evaluations indicate that the trialkyl phosphines are satisfactory gasoline additives.

To Order Paper No. 257 . . .

. . . on which this article is based, turn to page 5.

Table 2—Fleet Test Results—Tri-N-Butyl Phosphine Additive

(Test cars: 2 identical 1956 V-8's; test fuel: commercial premium gasoline—2.2 ml per gal. tel.)

Car No. 49					Car No. 50				
Deposit Miles	Engine Miles	Octane ^a Requirement	Preignition ^b Requirement	Plugs Fouled	Deposit Miles	Engine Miles	Octane ^a Requirement	Preignition ^b Requirement	Plugs Fouled
Phase 1. Cars Broken-In, Deposits Removed, Started on Country Driving Test									
No Additive					0.3 Theory Additive				
30	630	93	—	—	5	605	92	—	—
55	655	93	88.0	—	91	691	92	85.9	—
921	1,521	93½	91.9	—	941	1,541	92	88.0	—
1,810	2,410	94	94.0	—	1,820	2,420	93	90.3	—
2,690	3,290	96	94.0	—	2,650	3,250	93½	91.9	—
3,585	4,185	95½	94.0	—	3,530	4,130	93½	90.3	—
4,430	5,030	96	95.9	—	4,365	4,965	93½	94.9	—
5,295	5,895	95½	95.9	—	5,220	5,820	93½	91.9	—
6,175	6,775	96½	94.0	—	6,090	6,690	94	91.9	—
7,050	7,650	96	95.9	—	6,960	7,560	93½	94.0	—
7,925	8,525	96	97.0	—	7,810	8,410	93½	91.9	—
Phase 2. Deposits Removed, Fuels Switched, Restarted on Country Driving Test									
0.3 Theory Additive					No Additive				
0	8,525	92½	88.0	—	30	8,440	92	88.0	—
895	9,420	93½	90.3	—	872	9,282	94	90.3	—
1,790	10,315	94	90.3	—	1,750	10,160	94½	94.0	—
2,700	11,225	95	94.0	—	2,630	11,040	95	94.0	—
3,585	12,110	94	95.9	1	3,610	12,020	95½	95.9	—
4,480	13,005	94½	95.9	—	4,500	12,910	95½	97.0	—
5,410	13,935	94	94.0	—	5,370	13,780	95½	—	—
Phase 3. Both Cars Placed in City Driving Without Removing Deposits									
0.3 Theory Additive					No Additive				
6,060	14,585	94	94.0	2	6,007	14,417	95½	97.0	5
6,385	14,910	93½	91.9	—	6,360	14,770	96	98.3	—
6,780	15,305	93½	94.0	—	6,720	15,130	96	99.0	4
7,130	15,655	93½	94.0	—	7,060	15,470	96	98.3	6
7,490	16,015	93½	94.0	1	7,424	15,834	96	99.0	—
Phase 4. Car No. 50 Switched to Additive Fuel, Continued on City Driving Test									
					0.3 Theory Additive				
					7,620	16,030	95½	94.0	—
					7,827	16,237	94½	90.3	—
					8,040	16,450	94	91.9	—
					8,240	16,650	94	94.0	—
					8,410	16,820	94	91.9	—

^a In terms of primary reference fuels.

^b In terms of commercial reference fuels.

New Developments in Gear and Spline Production

Based on secretary's report by

Gordon Kousek

J. I. Case Co.

Gear Shaping

One recent development in gear shaping is a depth-feed-cam trip mechanism which eliminates overtravel. When the work spindle completes the last revolution, the depth-feed cam automatically advances, withdrawing the saddle carrying the cutter spindle from the workpiece. This eliminates gear "drop," or a thinning of certain sections of the gear tooth. A gear of higher quality results and heavier feeds can be used.

Shaper Cutter Sharpening Techniques

Improved gear quality and longer tool life can be achieved by using slightly different rake angles on shaper cutters. Tests indicate that the trailing side

of the cutter receives the most wear even though the leading side does the most work. Excessive wear occurs at the involute portion of the trailing side just below the corner chamfer or radius. This is caused by chips from the leading side flowing across the face of the cutter tooth and wedging between the trailing side and the gear.

Better wear can be obtained by having the rake angle direct the chip flow away from the cutter tooth.

On spur cutters, a 10 deg angle instead of the usual 5 deg will help considerably in reducing wear. In some cases, a 15 deg angle has been used successfully. Usually, a higher face angle tends to weaken the cutter, but a 0 deg sharpening approximately 0.020 in. from the tip will eliminate any tendency for the tooth to chip. On helical cutters, sharpening the angle about 8 deg less than the helix angle is beneficial.

Proper sharpening improves cutter life, reduces gear errors, and ultimately increases production.

Automated Pinion Gear Equipment

Now available is a completely automated setup for the smaller range of pinion gears. Blanks are put in the loading mechanism, fed to the shaper for cutting of the teeth, deburred, checked, chute fed into the shaving machine, and out.

Straight Bevel, Spiral Bevel, and Hypoid Gear Machines

Recent developments have now made available higher production spiral bevel and hypoid machines primarily designed for rear-axle drive gears. A newly developed helix tooth form has been produced by introducing an axial motion to the cutter as the finishing blades pass through the cut. This new helix tooth form gives greater axial pinion displacement without any sacrifice of tooth bearing quality.

There are new revacycle machines with greater rigidity that make it possible to produce coarse-pitch gears in one cut. This process previously required two cuts.

Also available are new straight-bevel generators that cut gears of a heavier pitch in one cut from the solid blank. These machines are primarily for cut-

SERVING on the panel which developed the information in this article were:

Del Hansen, J. I. Case Co., panel leader

Gordon Kousek, J. I. Case Co., panel secretary

S. Bjornberg, Illinois Tool Works

A. S. Black, Fellows Gear Shaper Co.

Edward Ball, National Broach and Machine Tool Co.

L. Patchin, Gleason Works

Ben Grob, Grob, Inc.

ting differential gears in moderate quantities that do not justify the more expensive high-production recycle system.

For spiral gears, there is now a greater range of machines available for the manufacture of prototype gear work at a minimum of capital investment and cutter investment.

Gear Shaving Practices

No one major factor is responsible for the difficulties encountered in gear shaving. Many little factors affect the quality of the gear. One of the primary problems, however, is tooth variation or "wobble". In checking a given number of teeth, normal inspection is concerned only about the average. But the vital factor is the extreme variation from one tooth to another.

Two things are essential in gear shaving:

1. A good quality gear blank—particularly that portion in contact with the arbor used for the gear cutting operation—to eliminate setting up a stress that will be released after the cutting of the gear, and
2. Precision arbors—particularly the nut type, where the face nut is square with the thread—so that in the drawing up of the gear blanks no stress is encountered which upon release will cause the gear to revert to a different shape than during the cutting operation.

Gear Honing Machine

A new gear honing machine eliminates the nicks, burrs, and upsets brought about during the handling and heat-treat operations. This improves the surface finish and results in better quality and performance of the gear. The machine utilizes a plastic gear which is impregnated with abrasive and looks not too unlike a shaving cutter, but operates at twice the speed.

Hobs and Gear Inspection

One of the big problems of the hob manufacturer is the speeds and feeds used in relation to the material being cut.

The hobbing industry is constantly striving to build hobs with greater accuracy and is now in the stages of attempting to establish standards for hob manufacturers.

Results with carbide hobs, up to now, are not too promising. They have been tried in high-speed hobbing but it will require some work on the part of the hobbing-machine manufacturer to build a rigid heavy-duty machine that is adaptable for the higher speeds. In addition, hob manufacturers will have to come up with the proper type of tool for the particular application.

Better and improved gear checking instruments are now available. This is particularly true with internal gear and spline checking instruments for the smaller range work.

Cold Forming of External Gears and Splines

One of the most interesting and latest developments in the manufacture of external gears and splines is a cold-forming process utilizing rollers which make up to 10,000 contacts per min in a swaging or extruding action.

The manufacturer claims the following benefits from the process:

1. Savings in material.
2. Production economy—a fast operation.
3. Exceptional hardening characteristics.
4. Superior finishes.
5. Extreme accuracy.
6. Exceptional toughness due to the shell and inner grain structure being uniform because of the method of cold forming employed.

This process is not limited as to the length of spline to be cut. In the case of torsion bars and similar applications, a spline being cut the entire length of the part results in an even twist throughout the length of the shaft.

It is possible with this process to cut an even or odd number of splines. The process can roll as coarse as 3 pitch, can form square or involute shapes, and can work practically all materials, including stainless steel.

▲ To Order SP-320 . . .

on which this article is based, turn to page 5.

Industry wants machine tools and cutting tools that provide greater accuracy, increased production, and economy of operation. This article describes some recent tools designed to meet these ends.

Designing for Aircraft Reliability

Five types of reliability must be matched in aircraft design and incorporated in preliminary design calculations.

Based on paper by

George S. Schairer and Herbert S. Clayman

Boeing Airplane Co.

An aircraft designer ought to understand and work toward five types of reliability, no matter what component he is considering. The five types of reliability cover the complete life span of the aircraft, from the first calculations to thousands of hours of service experience.

The types can be broken down as follows:

- **Safety**—Safety of personnel and equipment during operation.
- **Task**—probability that the next operation will be successful.
- **Nuisance**—Probability that no serious failures will occur during the next operation.
- **Maintenance**—Minimum line maintenance.
- **Overhaul**—Low cost and long intervals between overhauls.

The first four are concerned with the next flight, while the last is measured in time between overhauls and dollars.

Safety has been a prime objective of the aircraft

industry for so long that it tends to be set apart from other forms of reliability. However, all types of reliability are interrelated and must be balanced against each other. An example of this would be the lengthening of the period between overhaul of a component. This would reduce the overhaul work load and tend to increase overhaul reliability. However, the safety reliability of the component could suffer because of it.

Knowing the type of failure is a key to the design compromises in an airplane. One failure could be peculiar to a component in a mechanical, chemical, or electrical way. Another might be due to human inability to operate and service the aircraft. The designer must constantly keep the total reliability picture before him so his initial designs will offer the best total aircraft reliability.

Simplicity

Improvements in all five types of reliability are possible through simplifying or reducing the number of parts. This can often be accomplished by making one component serve two or more functions. However, the mixing of separate kinds of systems can lead to trouble. For example, a hydraulic pump with electrical controls will suffer if either system aborts.

The hard facts of complexity are shown in Fig. 1. As the number of parts goes up, so does the chance of failure. This graph shows the difficulty in just holding the reliability of present complex systems to past standards. Here, the type of reliability plays a part. A double system to do one function will increase the safety and task reliability, but cut into the nuisance and maintenance. If instead, the original design had been simpler and more reliable, all forms of reliability may have benefited.

Redundance Designing

Some parts cannot now be designed to give required reliability. Such a case might be the engine itself. Here, twin engines have a much lower probability of complete failure than a single engine. If design permits operation on one engine, the safety reliability is improved several thousand times, while the probability for one-engine failure is only doubled. Fig. 2 demonstrates this point and also shows that the chance of failure is greater immedi-

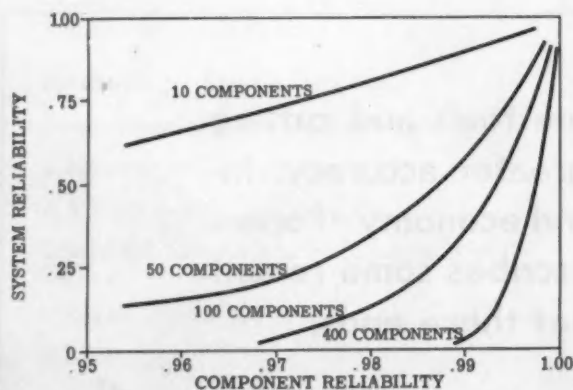


Fig. 1—Effect of complexity on reliability.

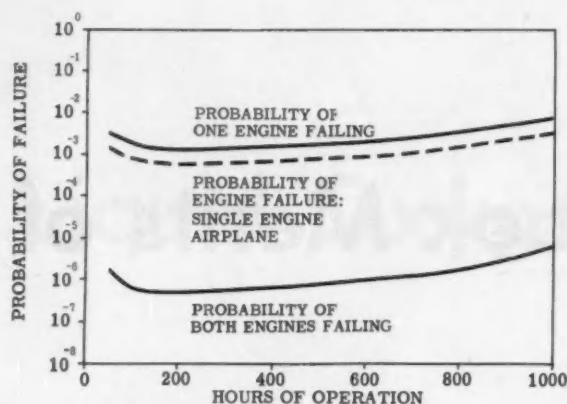


Fig. 2—Probability of jet engine failure per hour on a 2-engine airplane.

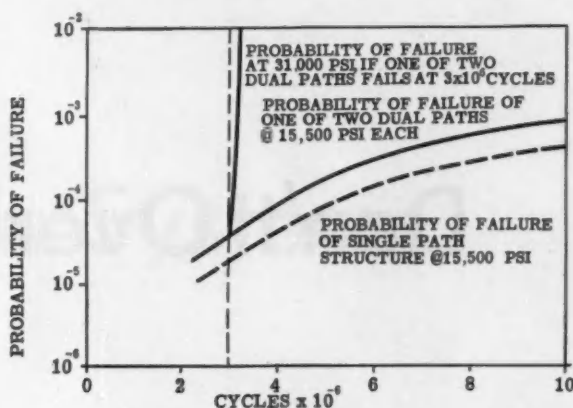


Fig. 3—Comparison between probability of failure per 1000 cycles for single and dual path structures.

ately after overhaul. This last point is typical of the human element.

Another use of redundancy in design is the dual path structure. Here, the load is divided between two members instead of being concentrated in a single larger member. If one of the dual members fails, there is still a chance that the other member will carry the load long enough to insure the safety of the personnel. Failure of one member is assumed at 3×10^6 cycles in Fig. 3. A small but significant chance of carrying the load is shown by the almost vertical line on the graph.

Failure Characteristics

An intimate knowledge of the nature of failures is a must for designers. Each part has its own characteristics of failure, and knowledge of these can aid reliability. Fig. 4 presents a typical set of vacuum tube failure data. Similar to other electronic equipment, there is a relatively high failure probability during the initial operation. This explains the widely used practice of a "burning in" period to weed out bad tubes prior to actual service. This would improve the first three types of reliability. The last two, maintenance and overhaul, could be improved by test equipment that would detect when the tube was wearing out. This would keep safety high while establishing economic replacement schedules.

Design Fixes

After the airplane has flown successfully, the problem of improving the reliability remains. The designer can use his knowledge of materials and components to spot trouble fast and fix it. If a fatigue failure occurs, he must compare the chance of this being a random occurrence against expectations that more failures are on the way. Consulting a graph such as Fig. 5 would show him that there is very little probability of a random failure of a part that was designed for a 21,000-psi stress. The chances are that the part is overstressed, and a fix should be ordered immediately.

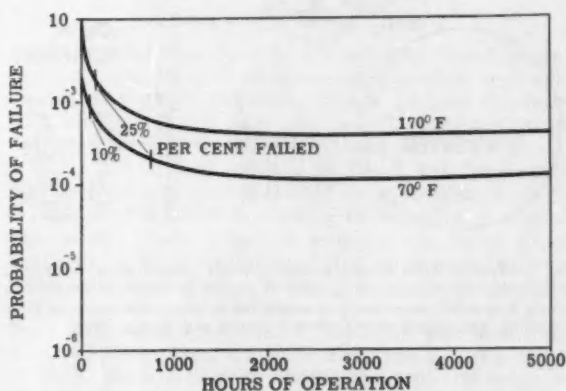


Fig. 4—Probability of vacuum tube failure per hour as a function of operating time.

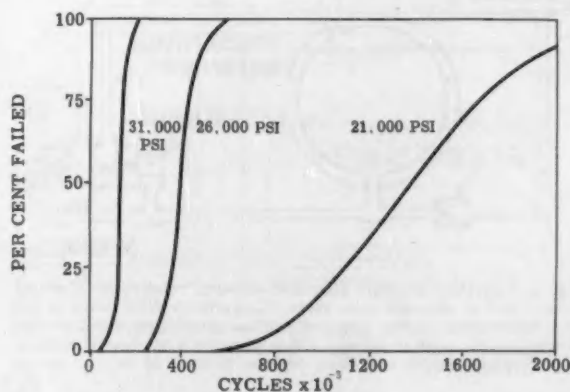


Fig. 5—% of 6061-T6 aluminum sheet specimens failed due to fatigue at three stress levels.

To Order Paper No. 222 . . .

... on which this article is based, turn to page 5.

Don't Overlook Merits of

Based on paper by

Paul L. Catron

El Segundo Division, Douglas Aircraft Co., Inc.

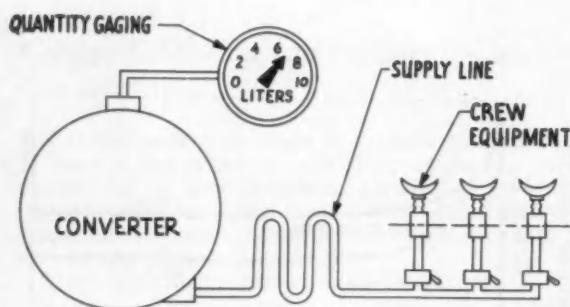


Fig. 1—Typical liquid oxygen system (aircraft portion only) comprising a converter for storage and delivery of oxygen at operating pressure, a supply line which vaporizes and warms the oxygen, crew equipment for breathing, and gaging system which measures and displays data.

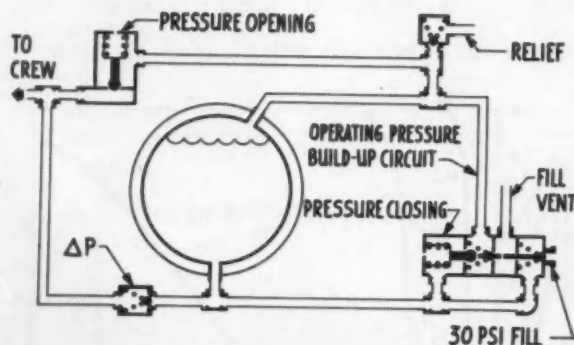


Fig. 2—Converter assembly schematic showing network of plumbing, fittings and six separate valve seats. Converter is filled while vented to ambient pressure and a special buildup circuit generates operating pressure to the order of 80 psi. Filling source is a low-pressure storage tank supplying oxygen at a filling pressure of about 30 psi.

TODAY'S liquid oxygen systems are an acceptable way to provide breathing oxygen for crews of military aircraft. But they are not perfect. Like just about every other system on an airplane, one could wish they were simpler and more reliable.

There's room for improvement in three directions:

1. Leakage prevention.
2. Length of filling time.
3. Gaging and presentation to pilot of data on oxygen remaining for the flight.

Fig. 1 shows a typical liquid oxygen system (aircraft portion only) and Fig. 2 the converter assembly schematic, to illustrate the discussion of basic shortcomings and what can be done about them.

Leakage

To meet operating and envelope requirements, the converter assembly may use approximately 40 connections and lines for connecting the valves, each a possible source of oxygen leakage. Service experience has shown excess oxygen loss to be caused most frequently by leakage through individual valves and fitting connections. The valves may leak because excess thread lubrication, metal chips from over-torqued fittings, dirt, or ice formation prevents poppets from reseating. The basic valve design can use a metal poppet and metal seat successfully, provided the sealing surfaces have durable finishes of a very high order and provided foreign particles are filtered out of the oxygen. "Soft" seat valves, using synthetics such as Teflon, Kel-F, or nylon, require less perfect surface finish to provide the same degree of sealing, and are frequently more reliable than metal seat valves. Valves, lines, and connections are nec-

Liquid Oxygen Systems

essary for converter operation, but elimination of excess parts is fundamental to converter simplification and reduction of leakage.

The converter can be simplified by filling it at operating pressure. This makes unnecessary a special pressure buildup circuit on the converter and may result in a simplified assembly which includes only four separate valve seats, as shown in Fig. 3. Such simplification can reduce potential leakage by about 30% and can result in greater reliability. The simplified converter can be filled at operating pressure, provided detail changes are made in the liquid oxygen storage tank.

The schematic of the present liquid oxygen storage tank shown in Fig. 4 is similar to that of the current aircraft converter assembly. The method of filling a converter is overly complicated and time-consuming because the storage tank valves are operated manually.

Inability to fill the converter rapidly may be caused by too little oxygen in the tank, flow restrictions such as dirty filters or partially opened valves, poorly insulated filler hose, or simply failure to regulate the storage tank pressure manually. The se-

quence of operations and attention demanded by current filling techniques lead to operators' mistakes and loss of time.

Length of Filling Time

There is no fundamental reason why liquid oxygen systems should not be filled as speedily and efficiently as a car is refueled, that is, plug in the hose, pull the trigger, fill, and unplug. Current technique can be improved by using different valves.

The storage tank, shown in Fig. 5, can be simplified so that the operator need only position a single 2-position valve for operating or securing the storage tank. Tank pressure can be regulated automatically and free the operator to concentrate on filling the converter. Existing converters are filled using a 30-40 psi storage tank pressure. In order to fill a simplified converter at working pressure (Fig. 3), the storage tank could be designed to store liquid at 75-80 psi equilibrium conditions and the transfer pressure could be generated and regulated auto-

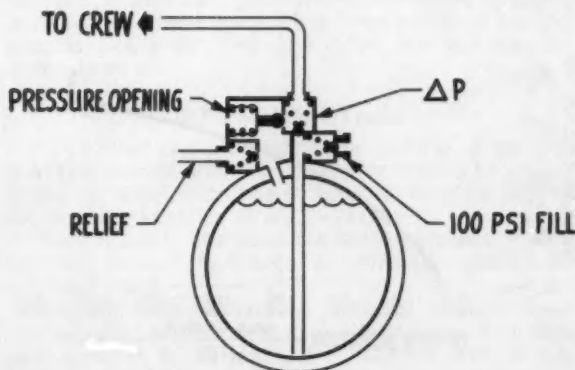


Fig. 3—Simplified converter which is filled at operating pressure. Special pressure buildup circuit is eliminated and valve seats are reduced to four. Potential leakage can be reduced by 30%.

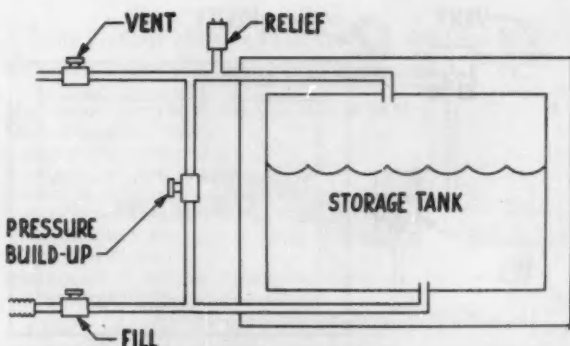


Fig. 4—Schematic of present liquid oxygen storage tank. Manually operated valves make filling of converter complicated and time-consuming.

matically in the same manner as shown in Fig. 5. A simplification of filling can aid greatly in getting the system airborne quickly.

Quantity Gaging

Inaccurate or unreliable quantity gaging can endanger a crew and cause a flight to be aborted. Whereas the quantity in a gaseous system was proportional to the gas pressure and temperature, and a simple pressure gage was used for quantity measurement, the liquid system operates at constant pressure. This has made it necessary to provide another method for gaging the quantity of liquid oxygen, a method that has introduced new problems of reliability.

Liquid oxygen quantity is determined by measuring the capacitance between two plates submerged in liquid oxygen. The gaging technique is basically sound, but the system is susceptible to contamination. Even though the capacitance measuring plates are close together, the capacitance change is small—on the order of 65–95 micro-micro farads for an empty to a full converter. The 0.050 in. gap between plates makes the gage sensitive to moisture and other foreign conductive materials which can cause shorting. To a lesser degree, the gage is sensitive to contamination which has a dielectric constant greater than oxygen. The moisture problem is virtually eliminated while the system is filled with oxygen, but shorting has been met frequently in empty converter assemblies.

The basic problem has been oxygen system contamination and there is as yet no full solution. Reliability can be improved by increasing the gap between capacitance plates. However, that requires a concern for an accompanying increase in surface area of the plates in order to maintain a capacitance

measurement which is compatible accuracy-wise with today's system. Investigations into radiation methods of gaging have been encouraging and further work may reveal it to be the more reliable method. Design foresight and improvement have resulted in a workable, capacitance type, quantity-gaging system which displays accurately the quantity of oxygen in the converter and this accuracy, in turn, may lead to the solution of a parallel problem—the method of displaying the measurements.

Presentation of Data

A pilot is not concerned directly with the amount of oxygen on board; he needs to know if oxygen endurance matches fuel endurance. Yet, the gage shows liters of oxygen remaining. As Fig. 6 shows, a liter lasts a variable length of time—42 man-min at sea level, 123 man-min at 25,000 ft. The designer specifies a converter size intended to allow completion of any foreseen mission, but pilot options of changing flight plans and the increased range made possible by in-flight refueling has aggravated the quantity display problem and emphasized the pilot's need for quantitative oxygen duration data.

A solution to the problem may lie in integration with a central computer. Supplying the computer with data in terms of rate of oxygen usage, cabin altitude, and time, coupled with fuel and aircraft performance data can result in a quantitative display of oxygen time. Even though the quantity measurement is accurate, the system may be considered unreliable unless the gaging data give a direct answer to the pilot's basic question of whether there is enough oxygen.

To Order Paper No. 238 . . .

. . . on which this article is based, turn to page 5.

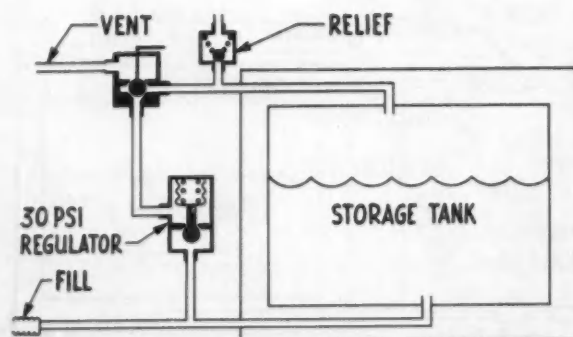


Fig. 5—Simplified storage tank. Operator positions a single 2-position valve for operating or securing the tank. Pressure is regulated automatically, so that operator can concentrate on filling converter.

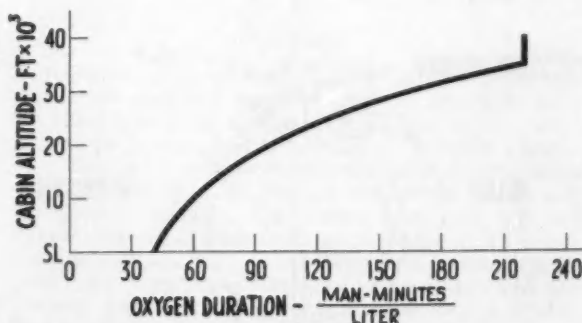


Fig. 6—A liter of oxygen lasts a variable length of time depending on altitude. Pilot needs to know if oxygen endurance matches fuel endurance rather than how much oxygen remains on board.

Fleets Save \$ \$

With Multigrade Oils

Based on paper by

L. J. Test and R. E. Greeger

Atlantic Refining Co.

FLEET operators are finding that the use of multigrade oils of the heavy-duty type is the most economical method of getting good low-temperature starting combined with excellent high-temperature performance and economy. The savings that can be realized depend on the location of the fleet and how it is operated.

In Place of Electric Immersion Heaters

For instance, one fleet that has been using electric immersion heaters for a number of years to help starts in cold weather has found it can save about \$17 per year per vehicle by switching to multigrade oil.

Until the advent of multigrade oils, immersion heaters were considered the cheapest way to ensure cold-weather starting. Approximate costs, based on 1952 figures were as follows:

Cost of heater plus installation in engine: \$35.

Installation of power lines, outlets, and so forth: \$250 per vehicle.

Cost of electric power (depends on location, severity of winter, use of trucks, and the like) estimated at: \$10-50 per vehicle per year.

Table 1 shows a cost comparison between using regular heavy-duty oil plus immersion heaters during the winter and year-round use of multigrade oil. A price of 60¢ per gal has been assumed for the regular heavy-duty oil and \$1.20 per gal for the multigrade oil.

In Place of Push Trucks

In another case, an estimated saving of \$60 per year per vehicle was obtained by switching to multigrade oil, which eliminated the need for push trucks for starting vehicles in cold weather.

Table 2 shows the data for this operation, where starting trouble had been encountered about 80 days per year.

Actually, it is difficult to estimate the complete cost of using push trucks as starting aids. The biggest question is the amount of loss involved in not getting the fleet rolling promptly. The drivers of these trucks are also being paid while they are waiting their turn to be pushed. A few bad mornings will buy a lot of oil.

To Order Paper No. 243 . . .

. . . on which this article is based, turn to page 5.

Table 1—Cost Comparison—Immersion Heaters and Regular Oil versus Multigrade Oil

(Typical Yearly Operation at Montello, Pa.)

Mileage per Truck	50,000
Oil Used—20 Oil Changes at 16 Qt. qt	320
Oil Additions between Changes, qt	80
Total Oil Used, qt	400
Cost of Regular Heavy-Duty Oil at 60¢ per Gal ^a	\$ 60.00
Cost of Multigrade Oil at \$1.20 per Gal ^a	\$120.00
Cost of Using Immersion Heaters (1200 W) ^b	
Cost of Heater, Power Lines, etc.	\$285.00
Cost per Year (7-Year Write Off)	\$ 41.00
Hours Used—12 Weekends at 36 Hr	432
60 Nights at 5 Hr	300
Total Time Used per Year, hr	732
Cost Electric Power at 5¢ per Hr	\$ 36.60
Total Cost per Year (Equipment and Power)	\$ 77.60
Cost of Using Immersion Heaters and Regular Oil	\$137.60
Cost of Multigrade Oil	\$120.00
Savings per Truck per Year from Using Multigrade Oil	\$ 17.60

^a List price.

^b Does not include the nuisance value of servicing, maintaining, and using this equipment.

Table 2—Cost of Using Push Truck at Syracuse, N. Y.

Number of Days Push Truck May Be Required per Year	80
Man-Hours per Truck Start (2 Men at 15 Min)	0.5
Man-Hours per Year	40
Cost per Man-Hour	\$ 3.00
Starting Cost per Truck per Year ^a	\$120.00
Cost of Regular Heavy-Duty Oil (See Table 1)	\$ 60.00
Total Cost—Regular Oil and Push Starts	\$180.00
Total Cost of Using Heavy-Duty Multigrade Oil (See Table 1)	\$120.00
Savings per Truck per Year from Using Multigrade Oil	\$ 60.00

^a This cost may be high, since it is based on a push being required on every cold day. However, no charge was made for using the push truck and, since it was kept in a heated garage used for repair work, no storage charge was made.

A straightedge and dividers are all

that's needed with this method of presenting

Hydraulic

Excerpts from paper by

Douglas B. Nickerson

Hydro-Aire, Inc.

A GRAPHICAL method of presenting pump data to determine readily the effects of changes in pump speed and scale is shown here. The technique requires no more than a straightedge and a pair of dividers after the original test data from the model have been plotted.

Being able to get results quickly is more important than accuracy in this process. In fact, the data themselves were not sufficiently accurate to warrant more than $\pm 2\frac{1}{2}\%$ scaling accuracy.

How the Method Works

This method is based on the following pump similarity laws: The head of a hydrodynamic pump is proportional to the square of the speed, and the flow is directly proportional to the speed of the pump. Or, if we are holding the speed constant and change the pump diameters, the head of the pump is proportional to the square of the diameter and the flow is proportional to the cube of the diameter.

In scaling a hydrodynamic pump, we multiply each linear dimension of the pump by a constant factor. It is just as though the pump were a complex balloon being inflated or deflated, with the similarity of all dimensions remaining intact.

A hydrodynamic pump at constant speed can operate over a very wide range of flows and, in the process, generate a wide range of different heads. The pump can be operated from zero flow at shutoff to a flow at which the pump output pressure is negligible. So, when we talk about the head and flow varying in proportion, we must take a head and flow point on the model pump characteristics and multiply these by the appropriate factors to get analogous points on the new head-capacity curve.

These analogous points have the characteristic of being points at which the inlet and outlet velocity triangles are similar. In other words, the velocity vectors representing inlet and discharge flow are separated by the same angles, the absolute value of the velocity being different. For a pump operating with similar flow triangles, the efficiency is constant

if we neglect scale effects. These analogous points in the sum total define a new head-capacity curve. To illustrate, if we wish to obtain the characteristics of a pump having a ratio of diameters D_1 to D_2 , the analogous head points are defined by the equation:

$$\frac{H_1}{H_2} = \left(\frac{D_1}{D_2}\right)^2 \quad (1)$$

The flow for these points is defined by the equation:

$$\frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2}\right)^3 \quad (2)$$

If the diameter ratio is eliminated from these equations, we get:

$$\frac{Q_1}{Q_2} = \left(\frac{H_1}{H_2}\right)^{3/2} \quad (3)$$

This equation is in the terms of the $3/2$ power of the head. Therefore, if we plot these analogous points on log-log paper, they will fall on a single straight line. This line would have a slope of $2/3$. (See Fig. 1.)

We can determine the distance along this line between the two analogous points as:

$$l = \sqrt{(\ln H_2 - \ln H_1)^2 + (\ln Q_2 - \ln Q_1)^2} \quad (4)$$

This reduces to the equation:

$$l = \sqrt{13} \ln \frac{D_1}{D_2} \quad (5)$$

If we define the scale factor S as a ratio of the diameters, equation (5) shows that, for a constant scale factor, the distance between analogous points is constant; and, thus, we have satisfied the requirements originally established. That is, if we plot on log-log graph paper our model pump head-capacity curve, then anywhere on this curve a constant ratio of diameters is represented by a fixed distance along these analogous point curves. Further, the analogous point curves are straight lines having a slope of $2/3$. To plot a pump characteristic, given the model head-capacity curve, we select a suitable number of points on the model curve, draw parallel lines through these points, and step off the distance from the model curve to the full-scale pump with a pair of dividers.

Pump Data

We have demonstrated that this method works well for a diameter change. The same reasoning can be applied to a speed change; except that the slope of the curve is 2/1 rather than 2/3. So, we have a graphical method of scaling from a model test curve to the full-scale pump.

There are other factors that we want to determine about the pump. These are primarily associated with the efficiency and shaft horsepower requirements. As shown in equations (1) and (2), the head varies as the square of the diameter and the flow varies as the cube of the diameter for points having constant efficiency. Thus, the power will vary as the fifth power of the diameter. As noted before, analogous points have the characteristic of being constant efficiency points, provided you ignore the scale effect which, for low viscosity liquids, and reasonable diameter ratios, can be neglected. Therefore, if we plot pump shaft horsepower against flow, we can use the same technique to scale up the shaft horsepower requirements. (See Fig. 2.) At this point, we must introduce one caution. Hydrodynamic pumps deliver a constant head of the pumped fluid, but this constant head may represent different values of pressure, depending on the density of the liquid. Therefore, in plotting head-capacity curves we can neglect the effect of the fluid specific gravity. But when we plot the pump power requirements, we can no longer neglect this factor. The power is the product of the flow and the specific weight times the head. Thus, the power curves must be for constant specific gravity and a correction must be applied to account for specific gravity changes. This is not difficult because the power ratio is directly proportional to the specific gravity ratio.

To the logarithmic plot of the shaft horsepower versus flow we can apply the same mathematical manipulations as before and show that the straight-edge-divider method will apply equally well in this case.

We have now shown a way of plotting pump data which permits the engineer to scale a pump—change its size and speed to meet the requirements of the particular situation. Fig. 3 is an example of how this works. The solid curve is the head capacity plot for the model pump. The dashed lines illustrate the slope of diameter change lines, and the phantom

lines illustrate the slope of speed change lines.

The speed change lines have a 2/1 slope and the diameter change lines a slope of 2/3. In this case, the problem is to design a pump which will have an output head-capacity curve passing through point R. In order to design a pump for this condition, we begin with the point on the model pump curve marked A. Through A we have drawn a size-increase line and a speed-increase line. We have the option of increasing the pump speed or the pump size. Let us assume that because of design consid-

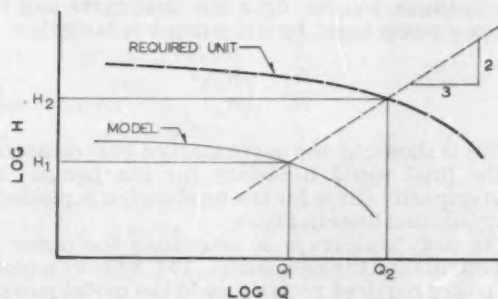


Fig. 1—Scaling chart of log head versus log flow.

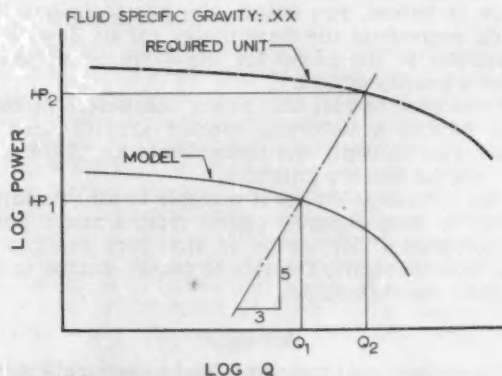


Fig. 2—Scaling chart of log power versus log flow.

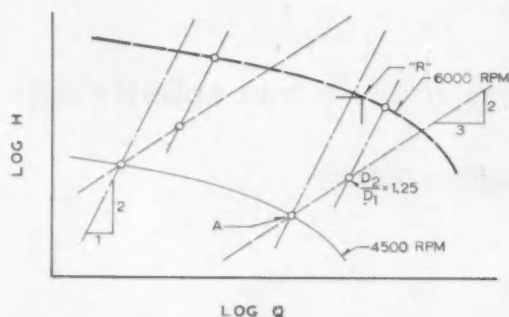


Fig. 3—Example showing how log head versus log flow scaling chart works.

eration we want to scale the model pump up by a scale factor of 1.25 and then adjust its speed to achieve the desired result. To do this, we step off a point on the size change line which corresponds to 1.25 diameter ratio. This is shown in Fig. 3. We then plot a new head-capacity curve by stepping off equal distances on parallel size change lines to show the output characteristics of a pump 1.25 times as large as the original model. In Fig. 3, we have shown a second point scaled up in this manner but have not drawn the head-capacity curve. From this new head-capacity curve for the larger pump, we now want to find the speed change necessary to meet the requirements. This is done by drawing speed change lines and stepping off distances necessary to pass through the point *R*. Once you have this distance, you can draw the final curve and find the new pump speed by the pump similarity law:

$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2} \right)^2 \quad (6)$$

This is shown by the curve marked 6000 rpm which is the final speed necessary for the pump. The head-capacity curve for the final design is plotted in heavy dashed lines in Fig. 3.

The next problem is to determine the power requirements for the new pump. Fig. 4 shows a plot of the power required versus flow to the model pump at a certain power for a fluid of 0.78 specific gravity. The dashed lines show the effect of increasing the diameter and the phantom lines again show the effect of increasing the speed. By following the same technique as before, you obtain the heavy dashed line which represents the final power versus flow characteristics of the pump for the same power and a specific gravity of 0.78.

If you wish to plot this power characteristic for a fluid having a different specific gravity such as water, you multiply the power scale by 1.00/0.78 or the ratio of specific gravities.

This technique makes it possible to plot rapidly a family of head-capacity curves from a model pump characteristic. By virtue of this very rapidity, it then makes it quite feasible to match pumps to the required characteristics.

Accuracy

The geometrical method is just as accurate as the plotting of the original pump data on log-log co-

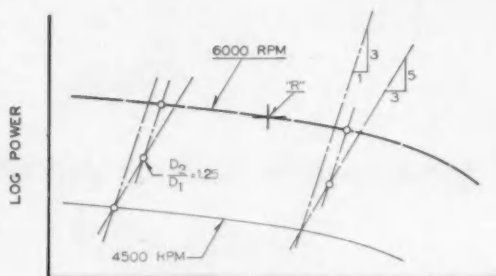


Fig. 4—Example showing how log power versus log flow scaling chart works.

ordinates can be. The degree of accuracy depends on such factors as the size of the chart used and the care with which the data are plotted. More important than the geometrical accuracy of the method are some of the other factors which tend to make a final pump different from the expected characteristics obtained by scaling from a model. The original test data depend on the laboratory and the care with which the tests were run. For a head-capacity curve for a normal aircraft tank booster pump, it is doubtful if most industrial laboratories achieve better than $\pm 1\%$. When you add to this possibility of error the fact that a curve is faired through the original data, it is doubtful whether the model test head-capacity curve can be depended on to better than $\pm 1\frac{1}{2}$ or 2%.

Viscosity effects for normal aircraft pumps are not important since the Reynolds number in the pump passages is well above the critical value. However, there may be some unusual cases where viscous liquids or fuel at very low temperatures are being handled. In these cases viscosity effects must be taken into consideration and the pump characteristics adjusted to account for them.

Probably one of the most important sources of deviation between the scaled-model characteristics and the actual head-capacity curve of the full-scale pump has to do with the fact that the process of scaling is inexact. The full-scale pump dimensions are not all multiplied by the same factor. To illustrate, if we are reducing the diameter of a pump impeller, it may not be practical to reduce the vane thickness in the same proportion as the impeller diameter. This would introduce an error in the capacity of the impeller at a given output head. Conversely, scaling up from a model impeller, it may be possible to reduce clearances to the point where leakage flows are a much smaller percentage of the pump output than was true of the model impeller. Then the efficiency would be improved and the flow would be higher than that predicted for a given head. Despite these deficiencies in the pump similarity laws, the graphic method of scaling pump impellers seems sufficiently accurate for the purpose intended.

To Order Paper No. 235 . . .

. . . on which this article is based, turn to page 5.

Contemplated Development Requirements of the Air Force

Presented as part of a panel discussion by

Col. Paul F. Nay

Chief, Air Force Field Office, Air Research and Development Command

THE purpose of this presentation is to provide you with the maximum amount of reasonable information on the trends in Air Force development.

Development Philosophy

At the present time and for the foreseeable future we are committed to a force in being, qualitatively superior but possibly numerically inferior to those of a potential adversary. This may be interpreted, based upon the present requirement, that we will be developing unmanned rather than conventional manned aircraft. Some of the chief design factors for the unmanned as opposed to the manned type of vehicle are the reduced vehicle-life requirements, increased operational speeds and temperatures, and relative freedom from corrosion.

Materials—The Key to Progress

At the present time, no factor is more important in aeronautical design than the availability of materials which will meet air weapons performance requirements. One constant objective of the Air Force is to improve the engineering technology through development and study of production and fabrication of new materials for air weapons.

Operational Environment

Current material selection for the air weapons which are on the drawing boards today is determined by the need to meet several distinct types of operational problems. Three of these are:

1. Aerodynamic heating.
2. Nuclear radiation.
3. High sonic intensities.

At the present time, the high-temperature problem is the most important consideration. The Air Force is, of course, approaching the solution of the temperature problem from several different angles.

The Impact of High-Temperature Materials

The present production capability of our air weapons contractors is based primarily on 25 yr experi-

ence in the forming of the lighter materials such as aluminum and magnesium. The fashioning of the harder, temperature-resistant materials into increasingly complex shapes constitutes a major transition from past practice. With the softer materials such as aluminum it has, in many instances, been common practice to start with a 500 lb billet and by machining techniques to end up with a 50 lb part and 450 lb of chips. We cannot afford this type of practice when machining complicated parts from the harder, temperature-resistant materials.

Plastic Forming Methods

At the present time, the problems and expense in time and dollars required to remove temperature-resistant materials in fashioning current designs is excessive. For this reason, ARDC is advocating that plastic forming techniques be employed to their maximum possible extent.

Chemical Milling

As we contemplate the problems of metal removal, the relatively new processes of chemical milling must not be overlooked. This technique may be found in many aircraft companies throughout the country and is being used in producing parts for at least twenty-one aircraft and missile models.

Chemical milling problems associated with the aluminum alloys have been successfully solved. And it now appears feasible to form parts from the various titanium and steel alloys by this chemical method.

New Materials Development

One current materials development which should tend to reduce rather than increase metal removal problems is popularly known as whiskers and refers to the production of fine strands of pure elements.

At present, it appears entirely feasible to redesign certain weapon structural parts to carry loads in tension and to employ stranded materials compressed and sintered to the desired shapes. The use of materials in this manner should provide equivalent strength with a weight saving of approximately 80%. It has been found that whiskers when permanently bent will recover to their initial unstrained condition upon heating beyond a critical level.

To Order Paper SP 321 . . .

... on which this article is based, turn to page 5.



At the three Cleveland National Meetings



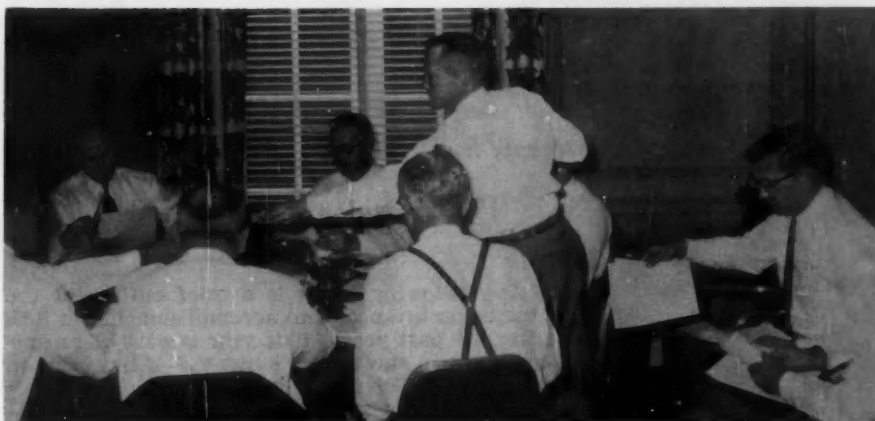
CHAIRMAN Charles Heinen (right) leads discussion of F & L Executive Committee meeting on the future and plans of the F & L Technical Committee in SAE.



DIESEL fuel stability and overlapping specifications were the subject of the F & L Diesel Fuel Subcommittee meeting. Chairman Grover Wilson is second from left.



A NEW membership brochure is finalized at the T & M Membership Development Subcommittee Meeting. Chairman Robert Gardner is second from right.



SIMPLIFIED lubrication of construction vehicles was the objective of a meeting of the CIMTC Ease of Maintenance Subcommittee. Chairman R. W. Beal is at left rear.



CONSOLIDATION of generator envelopes and mounting dimensions is the task of the Motors and Generators Subcommittee of the Electrical Equipment Committee. Chairman A. D. Gilchrist is at head of table.



MULTIPURPOSE gear lubricants were pinpointed at the meeting of the F & L Transmission and Axle Lubricants Subcommittee. Chairman A. W. Wright is at the left.



Message from

1957 President W. Paul Eddy

ON the following pages is a brief outline of the major occurrences and accomplishments in SAE during the past year. This year is part of an important era in the Society's history—it has been an interesting and dynamic period.

We are awakening to the need of a more flexible and progressive organization, better to handle the several new technical fields with which automotive engineering in its broadest sense must be concerned. Important constructive steps have been taken this year toward improving our national organizational structure in this respect, as well as toward increasing member participation and providing for continuity of experience in all phases of our technical and administrative work.

The Sections are often called the backbone of SAE. Most Sections are functioning effectively. There is one way in which I believe some of our Sections could improve their service and strengthen themselves—that is, by sponsoring and holding, each year, in addition to regular monthly technical meetings, self-supporting series of educational lectures or classes or forums on specific topics. I urge more consideration of these means of serving members and attracting new members.

Election to any office of SAE is, first, an assignment of work to do. It may be secondarily an honor or award for work previously done in furtherance of the Society's objectives; many members who are not elected to office are also entitled to such honor or award. At the conclusion of this year, I feel I should turn about and make an award to the Society. Serving as your President is an unmatched experience, and I am grateful to have had the opportunity of doing so.

The best part of the experience is the realization of the many hundreds of able men interested enough to take time to work for SAE, and the privilege of knowing and in a small way working with so many of those grand guys. For myself and on behalf of the Society, I thank all of you who have helped this year.

SAE Ahead

on All Fronts in 1957

THE Society's Planning for Progress Committee fittingly made the greatest contribution to long-term progress of any Society group during 1957. But practically every one of the Society's administrative and technical committees saw measurable gains take place in the areas of its particular activity.

Student Enrollment increased by 7%; there was a net increase in membership of 1,075; technical papers of specific interest to local members were presented at some 400 Section meetings to more than 42,000 members and guests; an increased number of projects of major significance to industry was completed by SAE technical committees . . . and the breadth of technical coverage in SAE publications was considerably increased.

Planned Progress Advances

In the van of this 1957 forward movement, the Planning for Progress Committee broadly defined the revised Society structure which it plans to propose to SAE Council.

The proposal in its current state grows out of analysis of both the present and future needs of the Society. It is keyed largely to the concept that SAE should have greater flexibility, offer an opportunity for increased member participation . . . and furnish more continuity in the leadership and administration of the Society's affairs.

This Committee currently has embarked on a third step in its program. Working closely with key committees, it asked for and got specific help and suggestions from knowledgeable members of these committees. Its aim is to incorporate this working committee thinking into the proposed program to make certain of its practicality and workability. Already consulted by the Planning for Progress Committee have been the Publication Committee, Finance Committee, Meetings Committee, Sections Committee, and the Membership Committee.

In addition, the 1957 Constitution Committee got well along in developing drafts of amendments and revisions needed to put into effect the changes in the Society's operating structure envisioned by the Planning for Progress Committee. The Constitution

Committee also is drafting a considerable number of detailed amendments mainly to improve or clarify present language.

Meetings' Technical Services Increased

Planned improvement of the technical content of papers and sessions for the Society's National Meetings took place in 1957. The meetings came closer than ever before to serving up technical information tailored to the current needs and interests of SAE members.

Groups responsible for programming National Meetings strove harder to spot problems facing automotive and aeronautic engineers and to shed light on these problems by way of papers and sessions. This aim was given added impetus by the contributions of special advisors and advisory committees to the SAE President in specialized areas—such as nuclear energy, small engines, and overseas information. The stage was set for even more of the same in the coming year. New presidential advisory groups were established during the year on missiles, electronic computers, and science-engineering relationships.

Of further help was the cross-fertilization of ideas provided through the assistance of SAE technical committees on several session programs.

Statistically, the 11 National Meetings held during 1957 maintained the gains in participation achieved during the previous year. Total registration at these meetings was 16,543. The three displays (in New York, Detroit, and Los Angeles), which contributed to the engineering value of those Meetings, made available an all-time high of 235 booths for exhibitors and produced a gross income of \$69,905.

Editorial Services Broadened

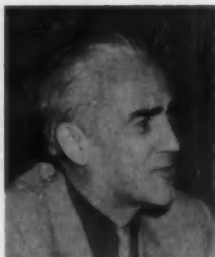
The breadth of technical coverage in SAE publications was increased considerably during 1957, reflecting the already-mentioned Society expansion in the areas of nuclear energy, overseas technical information, and computers. In addition, greater



R. R. Faller
Chairman
Constitution Committee



A. T. Colwell
Chairman
Finance Committee



A. O. Willey
Chairman
Meetings Committee



F. B. Lary
Chairman
Membership Committee



L. O. Ray
Chairman
Placement Committee

publication emphasis on missiles reflected the growing interest of SAE members in non-piloted as well as piloted aircraft.

The promptness and accuracy with which editorial services have been shifted—particularly in SAE Journal—was stimulated by member-opinion surveys brought to the Publication Committee by the nationally-known Eastman Research Organization. Based on Eastman reports also was a major revision in the format of SAE Journal's Table of Contents and Editorial pages . . . as was the decision to include the 1957 Index of SAE Journal as part of the December issue.

The quantity of technical information brought by SAE publications in 1957 is indicated by the following:

SAE Journal increased its average number of copies distributed monthly by 5.5%. . . . In 1956-57, SAE Transactions was bought by 37.6% of SAE members, as against 38.7% in the previous year . . . SAE Handbook went to 56% of SAE members, as against 54.6% the previous year.

Sections Procedure Revised

Following a year of study, the Sections Committee Executive Committee is putting finishing touches on a revised and expanded Sections Procedure. Indexed for ready reference, this guidepost for Section and Group officers and committee chairmen will be distributed to Governing Boards early in 1958.

Technical papers of specific interest to local members were presented at some 400 Section and Group meetings with overall attendance exceeding 42,000 members and guests. As in SAE publications and National Meetings, these Section discussions were accented by papers of particular interest to members whose careers are pointing toward missiles, satellites, nuclear power, and application of electronic computers to engineering problems.

Technical meetings continue to be the basic functions of Sections and Groups. However, 1957 saw emphasis on increasing SAE value to local members by sponsoring educational courses, forums, panel meetings, and expanded multi-session meetings on topics of particular local interest.

SAE Students in 109 Colleges

SAE's 53 Student Branches and 11 Informal Clubs had an active year and as a result, Student Enrollment increased by 7% to 4,893. SAE is now represented at 109 colleges in this country and abroad. Graduating Enrolled Students who continue in the automotive industry choose SAE as their professional society. Last year, 477 such graduates accounted for almost 20% of the additions to the Society's membership.

Membership Up Again

SAE membership took another step upward in 1957, closing the fiscal year with 22,771 active members. Additions to membership totaled 2,433 (names are listed monthly in the SAE Journal) while losses

amounted to 1,358, resulting in a net increase of 1,075. The end of year count showed:

Member	13,781
Associate	5,197
Junior	3,793

Certificates of recognition for long-time membership are being presented through their Sections to 69 members who have completed 25 years of active membership, 43 who have completed 35 years. One member, Richard F. Russell of Syracuse, received a special certificate upon completion of 50 years of active membership.

"Materials Engineers" and "Fleet Maintenance Men Want to Know" are titles of two new folders on membership added during 1957. Another new publication is "Membership Handbook" which is directed to membership committeemen. It answers questions regarding membership policies and procedures.

One of SAE's hardest working committees, the Membership Grading Committee, must go without public recognition because it can best work as an anonymous group. During the fiscal year it made recommendations to the Council on 2,497 applications for membership and 548 applications for transfer in grade. Included were applications from 68 candidates who failed to be elected because of insufficient technical training and experience. In most cases those turned down were young men who are potential members. These men are invited to reapply after securing additional qualifying experience.

Placement Adds New Service

The Society's Placement Service continues to list many more job openings than there are registrants to fill them.

It is currently extending its coverage by addition of an annual "SAE Consultants List." The first issue of this list will appear early in February 1958. It will be used to answer inquiries for consultants and also will be sent to the 1,000 prospective employers who now use the Placement Service.

Technical Reports Help Industry

Under Technical Board direction numerous projects were completed by technical committees during 1957, including the following which are of significance to industry:

- A great deal of previously unpublished material is included in the Iron and Steel Technical Committee report "Evaluation of Methods for Measurement of Residual Stress." The Committee also finalized a new Extra Heavy Duty Brake Drum specification.
- The SAE Lighting Committee supplemented revision to the dimensional standards for Sealed Beam units and the Lighting Inspection Code by issuing an SAE Recommended Practice "Headlamp Aiming Device for Mechanically Aimable Sealed Beam Headlamp Units" which is applicable to both the two and four headlamp systems.
- Extensive use of the new report "Front-End Loader and/or Shovel Bucket Rating" developed

M. A. Thorne
Chairman
Public Relations Committee



T. L. Swansen
Chairman
Publication Committee



T. R. Thoren
Chairman
Sections Committee



L. L. Otto
Chairman
Student Committee



A. E. W. Johnson
Chairman
Technical Board





B. B. Bachman
Treasurer

Financial Progress in 1957

For the year ending September 30, 1957, the Society had the highest income and highest expenditures in SAE history. Dues receipts set a new record, as did advertising revenues, investment income, and industry's support of the Technical Board program. Reserves attained a new high figure of \$1,016,000.

The SAE investment program is proceeding in line with the policy established by the Finance Committee and Council to take the advice of Bankers Trust Company within the prescribed limits of SAE financial competence and objectives. The principal elements of this policy are to limit investment in common stocks to 50% of Reserves; to look largely to common stocks as inflation hedges to maintain purchasing power of the SAE dollar and to look to bonds for stability. However, with respect to bonds, the Society more recently switched some of its government holdings into high grade corporate bonds with higher yield and good appreciation possibilities.

Certain realignments are occurring which will affect SAE, such as the transfer of military emphasis to the missiles program. Nonetheless, the Society enters the new year with optimism—tempered by the caution incident to any period of economic change.

Financial statements at September 30 appear on following pages.

by the Construction and Industrial Machinery Technical Committee has resulted in a more realistic determination of the capacities of loaders and/or shovel buckets.

- The SAE Aircraft Hydraulic and Pneumatic Equipment Committee established a new fifteen micron filter specification to improve the performance of hydraulic powered flight control systems for airframes and missiles.
- The Electrical Equipment Committee developed an adequate method of measuring wide band vehicle radio interference and is continuing in its work to establish acceptable limits so that suppression may be developed to reduce interference with television and two-way radio equipment.
- Helical designers and producers will find the Helical Spring Manual completed by the Spring Committee a valuable document.
- A method of determining objectionable sounds from motor vehicles was established by the Truck and Bus Technical Committee.
- Acceptance of the reports of the technical committees was pointed out with the distribution early in 1957 of the ten millionth "Aeronautical Material Specification."
- Of interest to the user are a number of reports including: recommendations for winterization components on heavy-duty equipment operating in the arctic prepared by the Construction and Industrial Machinery Technical Committee, an SAE Recommended Practice on Crankcase and Transmission Dipstick Marking completed by the Engine Committee, and the revised Truck Ability

Prediction Procedure resulting from the work of the Transportation and Maintenance Technical Committee.

Among the important NEW PROJECTS initiated during the past year are the following:

- Development of a series of Carbon Steel Hardenability Bands and a list of Alloy Steel Machinability Ratings in the Iron and Steel Technical Committee.
- Study and development of recommendations by the Aeronautics Committee regarding Oxygen Equipment for Transport Aircraft, and undertaking of standardization of design and techniques of flight control systems.
- Initiation by the Engine Committee of work on standardizing supercharger inlet and exhaust flanges for the exhaust and air connections.
- Continuation by all technical committees of work of reviewing existing reports bringing them up to date or discontinuing them as necessary.

CEP Income

Funds received to carry out the expanded SAE Cooperative Engineering Program totaled \$310,155—more than ever before.

This permitted CEP to come closer than in recent years to fulfilling the Council's stated policy of making this industry service a self-supporting venture.

Accountants' Certificate

Society of Automotive Engineers, Inc.:

We have examined the balance sheet of the Society of Automotive Engineers, Inc. as of September 30, 1957 and the related statement of income and expenses, and general reserve, for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet and statement of income and expenses and general reserve, present fairly the financial position of the Society at September 30, 1957 and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

November 18, 1957

Hastings & Sell

Balance Sheet

September 30, 1957

Assets		Liabilities	
General Cash	\$ 268,430	Taxes and Accounts Payable	\$ 108,883
Restricted Funds:		Section Dues Payable	33,215
Cash	14,454	Deferred Income:	
Securities (Market Value \$15,250)	17,915	Dues Received in Advance	260,679
Receivables (Less \$3,777 Reserve)	27,816	Journal Subscriptions	10,158
Investment Funds—At Cost:		Transactions	12,667
U.S. Government Discount Bills	x 99,108	Dinners and Displays	53,054
U.S. Government Bonds	x 164,311	Other	3,311
Corporate Bonds	x 308,982	Restricted Funds:	
Common Stocks	x 503,258	Memorial Funds	14,051
Cash for Reinvestment	7,600	Other	18,318
Accrued Interest on Bonds	4,563	General Reserve	1,016,444
Inventories	54,517		
Furniture & Fixtures (Arbitrary Value)	1,000		
Prepaid Expenses	58,826		
TOTAL	\$1,530,780	TOTAL	\$1,530,780

x Market Values at 9/30/57:

U.S. Government Discount Bills	\$ 99,140
U.S. Government Bonds	145,215
Corporate Bonds	288,700
Common Stocks	768,720
TOTAL	\$1,301,775

Statement of Income and

For Year Ended

Income

MEMBERSHIP

Dues and Journal Subscriptions	\$503,882	
Initiation Fees	38,475	
Emblem Sales	<u>1,581</u>	\$ 543,938

PUBLICATIONS

Journal and Transactions Sales	58,622	
Journal Advertising	596,059	
Handbook Sales	49,438	
Handbook Advertising	23,986	
Aeronautical Publications Sales	72,875	
Special Publications Sales	<u>64,972</u>	865,952

NATIONAL MEETINGS

Guest Registration Fees and Meeting Papers Sales	24,137	
Dinners and Luncheons	50,980	
Displays	70,355	
Summer Meeting Registration Fees	<u>10,875</u>	156,347

SECURITIES

Interest	12,448	
Dividends	<u>20,825</u>	33,273

CASH DISCOUNTS EARNED

2,043

INDUSTRY CONTRIBUTIONS FOR COOPERATIVE ENGINEERING PROGRAM 310,155

TOTAL INCOME

\$1,911,708

Expenses, and General Reserve

September 30, 1957

Expenses

SECTIONS AND MEMBERSHIP		
Sections Department	\$ 14,605	
Section Dues and Appropriations	82,213	
Membership and Student Department	51,297	
Miscellaneous Membership Expenses	1,161	\$ 149,276
WESTERN BRANCH OFFICE		29,309
PUBLICATIONS		
Journal and Transactions Editorial	246,630	
Roster (13th Journal Issue)	38,904	
Journal Advertising	282,955	
Handbook Production and Mailing—Editorial	69,031	
Handbook Advertising	9,522	
Aeronautical Publications	32,377	
Special Publications	42,234	721,653
PROFESSIONAL ACTIVITY COMMITTEES		
Department Expenses	46,466	
Awards	830	47,296
NATIONAL MEETINGS		
Department Expenses	44,354	
Guest Registrations and Meetings Papers—Costs	11,607	
Meetings	35,397	
Dinners and Luncheons	53,266	
Displays	16,040	160,664
COOPERATIVE ENGINEERING PROGRAM FOR INDUSTRY		
Technical Committees	178,788	
Handbook Editorial Salaries & Expenses	15,090	
CRC Appropriation	30,000	
Solicitation of Industry Contributions	15,752	239,630
ADMINISTRATIVE (See distribution on next page)		
General Management	162,107	
Service Departments	152,759	
Furniture and Equipment	16,347	
Council and Committees	9,418	
Employee Benefits	64,688	
Rent and Light	81,174	
Miscellaneous	7,110	493,603
TOTAL EXPENSES		1,841,431
EXCESS OF INCOME OVER EXPENSES (Before Special Charges)		70,277
SPECIAL CHARGES:		
New Headquarters—Furnishings, equipment, etc. (In addition to normal charges to administrative expenses)		20,766
Loss on disposal of investments		11,025
TOTAL		31,791
EXCESS OF INCOME OVER EXPENSES AND SPECIAL CHARGES		38,486
GENERAL RESERVE AT BEGINNING OF YEAR		977,958
GENERAL RESERVE AT END OF YEAR		<u>\$1,016,444</u>

DISTRIBUTION OF ADMINISTRATIVE EXPENSES TO DIVISIONS

To	%	Administrative Expenses Distributed	Direct Expenses	Total Expenses
Sections and Membership	11.1	\$ 54,790	\$ 149,276	\$ 204,066
Western Branch Office	2.2	10,859	29,309	40,168
Publications	53.5	264,077	721,653	985,730
Professional Activity Committees	3.5	17,276	47,296	64,572
National Meetings	11.9	58,739	160,664	219,403
Cooperative Engineering Program for Industry	17.8	87,862	239,630	327,492
TOTALS	<u>100.0%</u>	<u>\$493,603</u>	<u>\$1,347,828</u>	<u>\$1,841,431</u>

Where SAE Funds Came From . . .

- 28.4% MEMBERSHIP FEES AND DUES**
- 45.4% PUBLICATIONS SALES, INCLUDING ADVERTISING**
- 8.1% REGISTRATION FEES, DINNERS, AND DISPLAYS AT NATIONAL MEETINGS**
- 1.9% SECURITIES INCOME AND PROFITS**
- 16.2% CONTRIBUTIONS FOR TECHNICAL BOARD OPERATIONS**

. . . And Where They Went . . .

- SECTIONS AND MEMBERSHIP EXPENSES x12.8%**
- PUBLICATIONS, INCLUDING ADVERTISING x51.5%**
- PROFESSIONAL ACTIVITIES x3.4%**
- NATIONAL MEETINGS, DINNERS AND DISPLAYS x11.5%**
- TECHNICAL BOARD OPERATIONS x17.1%**
- EXTRAORDINARY EXPENSES 1.7%**
- NET INCOME ADDED TO GENERAL RESERVE 2.0%**

x Includes prorated administrative expenses



CEP

COOPERATIVE ENGINEERING PROGRAM

NEWS

Residual Stresses in Carburized Gears Spotlighted at ISTC Division Meeting

THE effects of material and processing variables on residual stresses in carburized gears were discussed by E. T. Bergquist, Chief Metallurgist, Western Gear Corp., at a meeting of the Iron and Steel Technical Committee's Division IV. The following summarizes Mr. Bergquist's report on investigative work performed under joint agreement with the Ordnance Tank-Automotive Command, Pacific Car Foundry, and Western Gear Corp.

Carburized gears of different materials were evaluated in terms of the effects that materials, carburizing media, heating methods, and quenching have on the residual stresses of various sample gears. The investigation was conducted within the following parameters.

Materials—ASI 4815, 4820, 8620, 1018, and 1045.

Gear Sample—14 tooth, 4 DP, 25-deg pressure angle, 3½-in. face width, 4-in. OD, with a 2-in. diameter by 1½-in. long hub on one end.

Carburizing Depths—0.040–0.060 and 0.070–0.09 in. range.

Case Depth—Effective case depth, measured at start of effective tooth profile.

Quench Methods—Direct oil quench, double quench in oil, direct brine quench, martemper, slow cool-reheat-oil quench, and slow-cool-reheat brine quench, martemper, slow cool-reheat-oil quench and slow cool-reheat-brine quench.

Samples were processed in the following areas of investigation. Gas carburizing, pack carburizing, induction heating, and retained austenite.

The beam dissection method was used for determining the residual stresses in the samples analyzed. There was no quench method which resulted in favorable residual compressive stresses for all materials and case depths. However, by averaging values for each quench method, the most

rapid quenches (brine) resulted in the highest indicated compressive surface stresses. The direct quench in oil resulted in the lowest residual compressive stress values when all materials and case depths were averaged. However, the difference between the highest average compressive surface stresses and the lowest average compressive surface stresses was only 12,000 psi. Of the three major variables considered in the investigation, (material, quench method, and case depth) none resulted consistently in a most favorable resid-

ual stress pattern for all conditions.

An optimum case depth appeared to exist for certain methods of carburizing and quenching in respect to the surface compressive stresses. In general, the deep case gas carburized samples resulted in the highest surface compressive stresses. No one material, of those tested, was consistently better for all quench methods and effective case depths. However, an average of all samples of each material gas carburized resulted in slightly higher compressive stress values for the 8620 material.

The process resulting in the highest surface compressive residual stress was found to be as follows: 8620 material, gas carburizing to .070 in. effective case depth, slow cooled, reheated and brine quenched.

High-Temperature Hydraulic Fluid Advances Reported at A-6 Meeting

THREE new silicone fluids, a new anti-wear additive, the silanes, and other high-temperature hydraulic fluids were discussed at the October meeting of Committee A-6, Aircraft Hydraulic and Pneumatic Equipment.

Luther Smith, General Electric Co., reported on the physical properties of three new silicone fluids: Versilube F-50, Silicone No. 81655, and Silicone No. 81717. Of these fluids, Mr. Smith said that Versilube F-50 is the most thermally stable. Thermal stability is practically unlimited up to 600 F, with breakdowns occurring gradually at temperatures above this. At 100 F, the breakdown rate is about 2%/hr. Under oxidative conditions, the fluid has unlimited stability up to 430 F, and will last up to 48 hr at 500 F with air being bubbled through the fluids.

Lubricity-wise, Versilube F-50 has wear resistance nearly equivalent to any natural or synthetic lubricant. It is able to support loads of approximately the same magnitude as that supported by non-additive diester fluids.

81644 contains all of the properties

of Versilube F-50, with the exception of slightly reduced thermal stability (4%/hr breakdown at 700 F and a thermal threshold of about 580 F). In addition, it has increased oxidative stability and almost unlimited life at temperatures up to 520 F. It will last up to 45 hr at 600 F with air being bubbled through the fluid.

81717 represents the maximum in silicone lubricity. At lower temperatures, its load-carrying capability compares favorably with natural or synthetic lubricants. At high temperatures (400–700 F), it demonstrates an outstanding slide contact capacity. It also has all the properties of Versilube F-50 with the exception of thermal stability (about 4–5%/hr breakdown and about a 580 F threshold temperature.) Oxidation threshold is slightly increased. Almost unlimited life can be expected at 450 F.

Bernard Rubin, Wright Air Development Center, told the committee of a new anti-wear additive which has succeeded in bringing the anti-wear level of silicones down to that of commonly used non-additive mineral oils and

esters. Mr. Rubin reported that in a relatively air-free system, the new fluid has properties which should allow operation over prolonged periods in the -65 to 575 F range. The additive-containing fluid shows somewhat less thermal stability than the base fluid. However, it should have short term use at the 650-700 F range. As yet, WADC has no performance or simulated per-

formance data to report.

Mr. Rubin also revealed the release of a new WADC Technical Report (57-168) which evaluates a large group of silane fluids. The study shows that physical and chemical properties of the subject silanes are of such magnitude that practical fluids in the 0 to 650-700 F range could be developed with further effort.

Flight Control Systems for Missiles and Manned Aircraft Studied by New SAE Committee



Chairman Leo M. Chattler is shown above charting a course of action for SAE's new Flight Controls Committee.

OPTIMUM performance requirements of flight control systems for missiles and manned aircraft will be studied by the new SAE Committee A-18, Flight Controls. Created as the result of demands from both industry and government, the committee will examine control system inputs (pilot, airframe data sensors, self-contained guidance) and output (actual control of aircraft flight path).

The first meeting has been tentatively scheduled for January 27-28 in Washington, D. C., by Chairman Leo M. Chattler, Chance Vought Aircraft, Dallas. The committee's structure will be discussed in terms of the following objectives.

- Coordination and acceleration of research and development of fundamental flight control systems for missiles and manned aircraft in areas of design, synthesis and analysis techniques, hardware, and application.

- Promotion of more effective flight control systems for military and commercial aircraft through the cooperative exchange of available technical information.

- Standardization of appropriate systems and related equipment in an effort to increase reliability and performance.

Chairman Chattler expects to organize three subcommittees, A-18A—Systems Requirements, A-18B—Piloted Aircraft, and A-18C—Missile Aircraft. Engineers from the major airplane and flight control system manufacturers, Navy, NACA, USAF, universities, research centers, and selected component manufacturers have been invited to participate in A-18 activities.

Key members are expected to take charge of one of the following major areas of flight control systems: Piloted aircraft system requirements, piloted aircraft automatic controls, piloted aircraft control systems, missile system requirements, missile control systems, missile guidance systems, synthesis and analysis methods, air data systems, mechanical controls, electronic systems, hydraulic and pneumatic systems, airframe dynamics, and analog and digital computers.

Several other items will be discussed at the January meeting.

- Requests to up-date, if necessary, MIL-F-18372, General Specification for Design Installation and Test of Aircraft Flight Controls System and MIL-F-9490A, General Requirements for Design, Installation, and Test of Flight Controls Systems.

- Revision of Buair's Flight Control Manuals (AE-61) I through VI.

- A request to develop artificial feel systems specifications or recommended practices.

Two New Flywheel Reports Approved by Tech Board

TWO new SAE recommended practices, *Flywheel for Industrial Engines Used for Single-Plate Spring-Loaded Clutches* and *Flywheel Housing Foot Mountings*, have been approved by the Technical Board. The former was developed to simplify the selection of flywheels for popular clutch sizes used on industrial engines. It has been under study for approximately three years and represents the views of technical personnel acquainted with the manufacture of both engines and clutches.

The recommended practice on flywheel housing foot mountings was established to simplify replacement of power units in construction and industrial machinery.

Both reports were prepared by the Construction and Industrial Machinery Technical Committee's Subcommittee VI on Industrial Engine and Power Unit Standards. They will be included in the 1958-1959 SAE Handbook.

Cetane Number Influences Diesel-Engine Performance

THE significance of the cetane number of diesel fuels is discussed in CRC Report No. 291A. A condensation of CRC Report 291, CRC Report 291A, "Significance of the Cetane Number of Diesel Fuels—Condensed Version," appears below unabridged.

Cetane number is the measure of the ignition quality, or tendency to ignite, as applied to liquid fuels for the operation of compression-ignition (diesel) engines. It is measured by an engine test procedure (ASTM Method D 613) in which the unknown fuel is matched against reference fuels of known cetane number. In the case of normal distillate petroleum fuels, cetane number can be estimated with good accuracy from the API gravity and the 50% point of the ASTM distillation by means of a nomograph. When determined this way, the ignition quality is called the (calculated) cetane index (ASTM Designation D 975).

Since the addition of ignition-improving additives to diesel fuels does not change the API gravity or the distillation of the oil, the actual cetane number will not be correctly indicated by the cetane index in fuels containing ignition promoters. The calculated cetane index also cannot be relied upon to give an accurate measure of the ignition quality of fuels containing heavy residual oils, crude oil, fuels of extremely high volatility (lighter than kerosene), or unusual fuel oils such as coal-tar products, vegetable or animal oils.

Diesel fuel oils of high cetane number differ from those of lower cetane

number by having a shorter ignition lag when injected into the diesel-engine cylinder. High-cetane fuel also is ignited at a lower compressed-air temperature than low-cetane fuel. These characteristics result in the following differences in the performance of high-cetane and low-cetane fuels in operating engines.

Starting—The higher the cetane number, the lower the temperature at which the engine can be started; but the range of starting temperatures differs for different engines. Furthermore, there is a lower limit for each engine below which starting can not be achieved by using higher cetane fuel alone. A practical example: if a given engine would start on 35-cetane fuel with intake air at 60 F, it might start at 30 F on 60-cetane fuel; but starting at 0 F could not be expected with 85-cetane fuel.

Warmup—After starting at low temperatures, engines may be brought to a state of steady running, without misfiring or emitting white smoke, more quickly on high-cetane fuel than on low-cetane fuel.

Combustion Knock—Combustion roughness or diesel knock, as well as shock loading of pistons, bearings and other engine parts, results when fuel having too low a cetane number is used for the size and type of engine and the conditions under which it is being operated. Use of higher-cetane fuel will give smoother combustion and reduce the noise and stress on the parts. The small, high-speed engines in automotive service usually require fuel of higher than 40 cetane number; while large bore, slow-speed engines can utilize fuel of lower ignition quality.

Engine Deposits—Low-cetane fuels may cause more rapid accumulation of varnish and carbonaceous deposits at idling and light-load operation than high-cetane fuels of the same grade. Such deposits are probably the results of the fuel composition per se rather than the result of poor combustion due to late ignition or low-cetane number.

Smoke, Fumes, and Odor—Higher-cetane fuel will help reduce the production of acrid odor and fumes (cold smoke) during light-load, cool-running conditions; but ignition quality has only a minor effect on black (hot) smoke. In some types of engines very high-cetane fuel (60 or higher) causes more smoke than fuel of lower cetane number.

Power and Fuel Consumption—Ignition quality has a negligible influence on output and economy. Low-cetane fuels, however, as long as they satisfy the cetane requirement of the engine, tend to give slightly more power at maximum output or lower fuel consumption than high-cetane fuels. This is because low-cetane fuels generally are heavier and therefore contain more heat units per gallon.

To Order CRC Report No. 291A
on which this article is based, see p. 5.

Technishorts . . .

A NEW CAST-IRON SPECIFICATION (SAE 115) has been established to meet the trucking industry's need for heavy-duty brake drums. Prepared by a division of Panel B of the Iron and Steel Technical Committee, SAE 115 has greater resistance to heat checking than the existing SAE 114, and at the same time, it provides good strength. Recently approved by the Technical Board, the specification will appear in the 1958-1959 SAE Handbook.

STARTER PINIONS AND RING GEARS, formerly an SAE recommended practice, has been designated by the Technical Board as an SAE standard. The report recently underwent an extensive review by the Electrical Equipment Committee, and is now considered representative of currently available high-production pinion gears. The standard will appear in the 1958-1959 SAE Handbook.

SERVICE BRAKE PERFORMANCE, a new SAE recommended practice, has been approved by the Technical Board. The report, which will appear in the next edition of the SAE Handbook,

describes highway and inspection station brake test procedures. It is similar to a provision in the new ASA Inspection Code which was essentially prepared by members of SAE's Brake Committee.

HIGH-TEMPERATURE LOCKWIRE (MS9226), which was recently approved by the Technical Board, will help air field maintenance personnel distinguish high-temperature (1800 F) steel lockwire from lower-temperature lockwire. Requested by the Services because of problems faced by maintenance people who, until now, had no reliable guide, MS9226 was developed by SAE Committee E-25, Engine and Propeller Standard Utility Parts.

PHOTOMICROGRAPHS OF PARTIALLY AND COMPLETELY DECARBURIZED STEEL SURFACES are being selected by a newly formed subcommittee of the Iron and Steel Technical Committee's Division 30B on Decarburization. Under the chairmanship of C. H. Leland, the subcommittee will select photomicrographs for inclusion in a report on methods of measuring decarburization now being prepared by Division 30B.

18 New, 2 Revised Aero Reports Released by SAE

EIGHTEEN new and two revised aeronautical reports have been released by the Society. They were issued November 15, and are available from SAE Headquarters. The new and revised ASs and ARPs may be obtained as a set or individually.

• AIR No. 34—Penalties in Performance of 3-Phase, 4-Wire, 4-Cycle Motors Caused by the Opening of One Phase

• AS 41E—Propeller Shaft Ends—Single Rotation

• ARP 419—Automatic Pilot Installations & Appendix A Thereto

• ARP 422—Spark Igniter Outline, Right Angle Flange Mounting

• ARP 423—Spark Igniter Outline, Flange Mounting

• ARP 424—Spark Igniter Outline, Threaded Mounting

• AS 468—Drive—Accessory, 5" Bolt Circle

• AS 469—Drive—Accessory, 8" Bolt Circle

• AS 470—Drive—Accessory, 10" Bolt Circle

• AS 471—Flange—Accessory, 5" Bolt Circle

• AS 472—Flange—Accessory, 8" Bolt Circle

• AS 473—Flange—Accessory, 10" Bolt Circle

• ARP 475—Gasket—Spark Igniter

• AS 481—Flange Pilot—Accessory, 5", 8", 10" Bolt Circle

• ARP 484—Nomenclature for Spark Igniters

• ARP 485—Temperature Measuring Devices Nomenclature

• ARP 492—Aircraft Fuel Pump Cavitation Endurance Test

• ARP 494A—Terminals—Input and Output—Ignition Exciters

• ARP 569—Drive—Miniature, Power Motor with Involute Spline-Pinion

• ARP 576—Outline and Instructions for Preparation of Model Specifications for Hydraulic System Equipment



Holzapfel

Hazard

Potts

Cubicciotti

Goodrich



Stout

Otto

Freedlander

Bradley

Malone

HARRISON HOLZAPFEL, 1958 SAE vice-president representing Aircraft Activity, has been named manager of the AIRsearch Aviation Service Division of The Garrett Corp. Prior to his new appointment, he was assistant manager of the division.

Holzafel joined Garrett in 1956, after serving with Lockheed Aircraft Corp., and at other Southern California aircraft companies. He served as head of Western Air Lines', Inc. engineering department for the 10 years prior to joining Garrett.

A member of SAE since 1949, Holzafel has served as vice-chairman for Aeronautics of the Southern California Section, and has been active on Aircraft and Air Transport Activity Committees since 1949.

ALBERT C. HAZARD has been made power unit engineer for the Brazilian Truck Mfg. program of General Motors Overseas Operations, at Sao Paulo, Brazil. Among his new responsibilities will be engineering and testing of engine parts produced in the new General Motors foundry and machine shop, as well as parts procured from local Brazilian manufacturing sources.

Hazard, who has been with GMC since 1919, served as assistant staff engineer in the Chevrolet research and development department prior to his new appointment.

FRANK POTTS, former manager of the Montreal branch of the White Motor Co. of Canada, Ltd., has been made assistant to **KARL A. ROESCH**, vice-president of the White Motor Co. and general manager of the Autocar Division, Exton, Pa. Potts joined the company in 1952 and had been Montreal branch manager since 1953.

RUDOLPH CUBICCIOTTI, vice-president of L. Sonneborn Sons, Inc., has been elected president of the National Lubricating Grease Institute. Formerly he was vice-president of the

institute. He has been with L. Sonneborn Sons since 1943.

New members of the board of directors of the Institute include **W. H. SAUNDERS, JR.**, president of International Lubricant Corp., and **B. G. SYMON**, manager, industrial products department, Shell Oil Corp.

FRANK I. GOODRICH, vice-president — administrative, Eaton Mfg. Co., has been elected to the board of directors. As vice-president — administrative, he directs the activities of all Michigan divisions of the company.

Goodrich has been with the company since 1925, and for years was general manager of the company's Spring Division in Detroit.

ERNEST G. STOUT has recently been made a member of the board of directors of the Air Craft Marine Engineering Co. of Van Nuys, Calif. In addition, he has been transferred from the home office of the Ralph M. Parsons Co. in Los Angeles, where he was manager, nuclear department, Project Development Division, to the Washington office of the company, where he is now assistant manager.

HERBERT OTTO, JR., formerly chief engineer, Purolator Products Inc., is now chief engineer and executive vice-president with the Lee Filter Corp. of Arlington, N. J. He has been in the filter industry for 16 years and is recognized as an authority on modern filtration.

A. L. FREEDLANDER, chairman of the board of Dayton Rubber Co., has been named a Knight of the Royal Order of St. Olaf—the highest honor the country of Norway may bestow upon a civilian. Official presentation of the honor was made by the Norwegian American Chamber of Commerce during a meeting at New York's Advertising Club. Freedlander has been with Dayton Rubber since 1919.

About

DAN T. BRADLEY has been named vice-president and technical adviser for Clevite Harris Products, Inc. He will devote most of his efforts to coordinating the company's advance planning and research, and expanding foreign contacts and licensing arrangements. Previously he was vice-president in charge of engineering and sales.

JOHN M. MALONE, electronic equipment sales manager of Tung-Sol Electric, Inc., has been named assistant general sales manager for the company.

V. Y. TALLBERG has retired as special assistant to the vice-president — engineering and research, Ford Motor Co. Tallberg has been with Ford since 1928.

For 12 years, Tallberg helped organize Ford operations in Germany and directed engineering at the company's plants there. He returned to the U.S. in 1940. In the last decade, he has directed expansion of Ford's central engineering staff from 1,000 to 10,000 persons, and has had a key role in planning the company's Research and Engineering Center, to be completed next year.

DAVID T. SAUNDERS is president of General Schools Corp., Portland, Ore., which recently was organized to develop training programs especially adapted to the needs of the diesel, tractor, and heavy equipment industry in anticipation of the increased use of construction machinery in the Federal highway program and other construction projects. Saunders previously was vice-president and training program director, Tractor Training Service, also of Portland.

CLINTON F. HEGG has been elected to the board of directors of L. O. F. Glass Fibers Co. He is vice-president and general sales manager of the firm and has been with it since 1939.

SAE Members

SYDNEY S. GUY, founder of Guy Motors, Ltd., of Wolverhampton, England, has retired as chairman and managing director of Guy Motors and its associate company, the Sunbeam Trolleybus Co., Ltd.

After studying at Birmingham Technical College, Guy served an apprenticeship with Belliss & Morcom, Birmingham engineers. Subsequently he went to General Electric Co., Ltd., later became service manager of Humber, Ltd., and in 1908 joined the former Sunbeam Motor Co., Ltd., as works manager. He left Sunbeam in 1914 and formed Guy Motors, Ltd.

MAURICE NELLES, former director of diversification and research development for Technicolor Corp., Hollywood, has been made vice-president for engineering of Crane Co., Chicago.

LESTER C. WINSLOW, formerly Detroit district sales manager with Clevite Harris Products, Inc., has become assistant general sales manager. He will have charge of all auto industry sales for the company.

Winslow joined Clevite Harris as a sales engineer in 1935; he is the company's oldest employee in point of service.

WILLIAM P. SPENCER is now field engineer, Detroit district, National Seal Division of Federal-Mogul-Bower Bearings, Inc. Formerly he was a field representative for the company in Indianapolis.

ALLEN H. GLASENAPP has joined Mack Trucks, Inc., as executive assistant to the vice-president — engineering. Previously he was chief engineer, diesel engine section, Construction Equipment Division, International Harvester Co.

IRVIN G. DETRA has joined Mack Trucks, Inc., as executive engineer in charge of the gear design department. Formerly he was chief design engineer — automotive transmissions, New Process Gear Division, Chrysler Corp.

WINTON J. PELIZZONI has been made assistant executive engineer, engine design department, Mack Trucks, Inc. Formerly he was manager of Mack's testing laboratory at Plainfield, N. J.

M. E. CARROLL, director of field sales, has been made general sales manager of Minneapolis-Moline Co. He assumes responsibility for all of the company's sales operations and has charge of the departments of market

research, advertising, customer services, parts, technical publications, and service. He joined the company in 1936 and in 1956 became director of field sales.

ROBERT S. KINSEY has been appointed director of engineering, Utica Division, Bendix Aviation Corp. He will also be responsible for the operation of the air turbine test laboratory at the Eclipse-Pioneer Division, Teterboro, N.J. He had joined the staff of **RAYMOND P. LANSING**, vice-president and group executive, this past summer.

MARTIN E. KEANE is now a mechanic with the Mack Truck Co. in Los Angeles. Prior to this he was a foreman with the company in Chicago.

JEFFERY L. WEST, formerly senior engineer, Wright Aeronautical Division, Curtiss-Wright Corp., is now studying for an MBA degree at Harvard Business School.

CHARLES A. HATCHARD, formerly assistant service manager, Overseas Division, Ford Motor Co. of Canada, is now supervisor, technical service department, Ford Motor Co. of South Africa Pty., Ltd.

CARL BAILYS, formerly chief metallurgist, Long Mfg. Division, Borg-Warner Corp., is now staff engineer, materials section, missile operations, Chrysler Corp., Detroit.

DONALD ALBERT BODLEY, formerly with the Board of Missions of the Methodist Church as a missionary and office worker, is now staff engineer with A. E. Friedgen, Inc., New York City.

RICHARD M. CORS, formerly sales director, Outboard Motor Division, Oliver Corp., has been appointed to the newly created position of national marketing director with the Klekhaefer Corp. Following several years in executive capacities in the marine field, Cors returns to the corporation with which he had previously served in service and sales positions.

JOHN PERRY, formerly manager of manufacturing, motors, Manufacturera General Electric, S. A. de C. V., Mexico, is now with the International General Electric Co. in New York City.

FRANCIS L. GALLANT is now a design specialist, ram test facility, Aircraft Gas Turbine Division, General Electric Co., Cincinnati. Formerly he was division manager, engineering test facilities, Wright Aeronautical Division of Curtiss Wright Corp., Woodridge, N. J.

CARL E. CLUTTER, formerly mechanical specialist with General Electric Co., Cincinnati, is now design su-



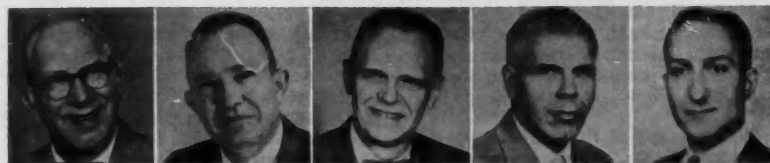
Tallberg

Saunders

Hegg

Guy

Nelles



Winslow

Spencer

Glasenapp

Detra

Pelizzoni

pervisor with the Production Design Service, Inc., Dayton.

NORMAN EDWARD DELMAGE, formerly maintenance supervisor with the Iron Ore Co. of Canada, is now assistant master mechanic, Consolidated Denison Mines, Ltd., Spragge, Ont., Can.

ERNEST J. HAAS, General Electric Co., has transferred from Cincinnati to West Lynn, Mass.

M. F. SPERRY has retired as district sales manager of the Pittsburgh district sales office, Reo Division, White Motor Co.



HAROLD S. VANCE, member, U. S. Atomic Energy Commission, recently likened the development of atomic energy and the beryllium industry to the early development work of Thomas A. Edison—and described atomic power as “the final reason for world disarmament.”

An SAE member since 1927, Vance spoke at the dedication of a beryllium metal plant of the Brush Beryllium Co.

RALPH E. CROSS, executive vice-president of the Cross Co., explained automation in the manufacturing industries at the 12th annual Industrial Productivity Conference. It was held at the Illinois Institute of Technology, December 5 and 6.

JOHN E. BRENNAN, vice-president, Chrysler Corp., received a citation for management leadership October 25 from The National Management Association. Brennan spoke during the NMA's 34th National Conference in Pittsburgh.

ROBERT TWELLS, vice-president of Electric Auto-Lite Co., is now group executive in charge of the Spark Plug Division. Twells joined Auto-Lite in 1935 and was made a vice-president in 1948. He was manager of the company's Spark Plug plant at Fostoria, Ohio, prior to his new appointment.

CHARLES L. ELLIS has joined the Clark Equipment Co. as field engineer. Formerly he was field engineer with the LeTourneau-Westinghouse Co.

PAUL O. NELSON, formerly project engineer, International Harvester Co. C.E.E.D., is now department head, advanced development and research, Walker Michigan Division, Walker Mfg. Co.

HAROLD J. BERGUM has joined Nylok-Detroit Corp. as plant manager in charge of the company's new manufacturing facilities at Troy, Mich.

Prior to his new position, Bergum was with the Ford Motor Co. where he was engaged in engine design and development within the engineering department.

V. P. MASI, formerly manufacturing manager of the Mound Road Engine plant, has been named plant manager of the Joseph Campau Engine plant, Engine Division, Chrysler Corp. Masi joined Chrysler in February, 1957.

L. PAUL ATWELL has become chief engineer of the Spark Plug Division, Electric Auto-Lite Co. He joined Auto-Lite in 1949 and was assistant chief ignition engineer prior to his new position.

JOHN F. CREAMER of Wheels, Inc., discussed “The Automotive Service Industry” in the program “Earn While You Learn” on November 8. It was presented on Channel 11 by the Board of Education in cooperation with WPIX and the Metropolitan Educational Television Association.

HARRISON W. SIGWORTH is now product engineer with the Standard Oil Co. of Calif. in San Francisco. He will assist in field testing of new developments by California Research Corp., subsidiary of Standard Oil, for which he was research engineer prior to his new position.

WILLIAM J. HARRIS is now technical adviser to the president of Faleen Drop Forge, Inc., Manistee, Mich. Formerly he was manager, manufacturing research, Studebaker-Packard Corp.

ARTHUR SHAW has been made assistant chief engineer, Moraine Products Division, General Motors Corp. Shaw has been with Moraine Products since 1937 and was section engineer in charge of the engineering laboratory, experimental garage, model shop, drafting room, and engineering orders, which activities he will continue to direct.

FRANCIS J. MARKEY is now sales manager of automotive assemblies, Moraine Products Division, General Motors Corp. He has been with GM since 1931 and was sales manager of automotive products prior to his new position.

New officers of the Truck Body and Equipment Association, Inc., include **FEARSON S. MEEKS**, owner, S. J.

Meeks' Son, Washington, D. C., — president; and **PAUL R. HAFER**, president, Boyertown Auto Body Works, Inc., Boyertown, Pa., — secretary-treasurer.

CAMERON N. LUSTY has joined Avien, Inc., as weapons system consultant, a newly created position. Formerly he held engineering and technical management posts at Lycoming and Crosley Divisions of AVCO Mfg. Co.

LOUIS POLK, vice-president of the American Ordnance Association, president of the Sheffield Corp., and vice-president of Bendix Aviation Corp., presided over a program of seminars at the 39th Annual Preparedness Meeting of the AOA. The meeting was held in cooperation with the Cornell Aeronautical Laboratory, Inc., at the Waldorf-Astoria on December 4, with “Capabilities and Techniques of American Armament for Limited War” as its theme.

CHARLES LAWRENCE SCHNEIDER, former executive vice-president of Fruehauf Trailer Co., has been elected president and a director of Trans Continental Industries, Inc.

Schneider is past-president and director of the Truck-Trailer Manufacturers Association, Inc., and a member of the Office of Defense Transportation's Trailer Committee. He has been a member of SAE for 25 years.



BRIG. GEN. WILLIAM S. JOHNSTON, AFRes. (right), president of Johnston Cadillac, Inc., receives the U. S. Department of Defense Reserve Award on behalf of the corporation from Maj.-Gen. Homer L. Saunders, (left), U.S.A.F. The citation, presented in Trenton, N. J., on November 19, paid tribute to Johnston Cadillac for policies which over the years have encouraged participation in the reserve and have promoted the military reserve programs in the community.

JOHN ALBERT SWINT, formerly plant manager, Sterling Plant, Ford Motor Co., is now president of Vard, Inc., in Pasadena, Calif.

WILLIAM COX, JR., vice-president of the Elco Lubricant Corp., will also serve as chairman of Elco's board of directors. He has been with the company since 1929.

RALPH F. PEO, president of Houdaille Industries, Inc., has been elected chairman of the Higher Education Assistance Corp. The corporation was created to make low-interest loans to needy college students, using private capital.

E. O. COOPER has been made general manager of Bendix West Coast Sales and Service, a division of the Bendix Aviation Corp. He will direct the servicing of Bendix aircraft equipment in seven western states.

Cooper joined the Bendix staff in 1929 and was service manager of the division prior to his new position.

GEORGE M. BUNN has established the consulting firm of George M. Bunn & Associates at 832 Woodbrook Lane, Norristown, Pa., to work in the field of transportation engineering. Bunn will continue as a consultant to Baltimore Transit Co. where, in recent months, he has set up extensive diversification programs. His practical experience as a transportation engineer in the motor truck industry goes back nearly 40 years.

OTTO W. VATHKE, technical editor, SAE Journal, has been elected to Tau Beta Pi, honorary engineering fraternity, and to Pi Tau Sigma, national honorary mechanical engineering fraternity. Within a few months he will have completed his studies toward a degree in mechanical engineering at Brooklyn Polytechnic Institute.

R. C. ALDEN, chairman of the research planning board of Phillips Petroleum Co., has retired after 32 years with the company. He joined Phillips in 1925 during organization of the research department and became director of research in 1933. He has served in his present capacity since 1950.

Alden has written numerous articles for scientific and trade publications and was the first recipient of the Hanlon Award of the National Gasoline Association of America. He is a director of the American Society for Testing Materials, the University of Oklahoma Research Institute and of the Coordinating Research Council, Inc.

LEO E. NOVAK, formerly mechanical engineer with Truckstell Mfg. Co., is now project engineer with Dairypak, Inc., Cleveland, where his work ranges from new building construction to process machinery and tooling.

Ford Appointments



Frey



Haynes



Wauters



Howes

Four executive promotions have been announced by Ford Motor Co.

D. N. FREY, formerly director of the engineering research office, engineering staff, Ford Motor Co., has been named executive engineer, Ford Division Car Product Engineering, Ford Motor Co. He will be responsible for development and engineering of Ford cars.

A. L. HAYNES has been made director of the engineering research and advanced product study office, engineering staff. Previously he was on

the engineering staff as an executive engineer, and in April became director of the advanced product study office.

A. M. WAUTERS, former associate director of the engineering research office, becomes special assistant to HAYNES.

BENJAMIN T. HOWES, formerly section supervisor, project coordination, Gas Turbine Division, Ford Motor Co., has been made associate director in charge of departments within the engineering research office.

W. R. GERBER, formerly general superintendent of the pressed steel division at the Dodge Main plant, has become plant manager of the Conant Stamping plant, Stamping Division, Chrysler Corp. Gerber joined Dodge Brothers in 1918.

On page 97 of our November issue, SAE Journal incorrectly stated that H. M. Smith, engineer in the engineering

services section, Technical Service Division, Ethyl Corp., has previously been with Esso Research and Engineering Co. This Mr. Smith, **H. MARVIN SMITH** (J'56), has never been with Esso.

Another Mr. Smith, **HARLAN M. SMITH** (M'53) has been with Esso Research and Engineering Co. since 1949 and is still active in that organization.

Obituaries

JOHN VIRGIL BRAZIER ... (M'36) ... operations manager, Dealers Refining Co. ... served actively in the SAE Mid-Continent Section and on its Governing Board in several capacities ... died Sept. 5 ... born 1897 ...

CLAYTON R. BURT ... (M'14) ... president and chairman of the board, Pratt & Whitney Aircraft, division of United Aircraft Corp. ... joined the company in 1924 as general manager ... died October 21 ... born 1874 ...

E. H. FEZANDIE ... (M'24) ... professor of mechanical engineering at Stevens Institute of Technology and a partner in the consulting-engineering firm of Greysgang, Fezandie & Moser ... graduate of Columbia University ... member of faculty of Stevens Institute since 1922 ... died November 10 ... born 1898 ...

JOHN A. JONES, JR. ... (M'51) ... manager of lubricant and special sales,

California Oil Co. ... joined the company in 1930, made assistant to vice-president in 1947, and assumed last position in 1956 ... died Oct 1 ... born 1907 ...

BERT LAMPE ... (J'55) ... had been serving in U. S. Army ... formerly junior test engineer, Curtiss-Wright Corp. ... received BME degree from City College of New York ... died recently ... born 1931 ...

D. GLENN MORGAN ... (M'50) ... retired director of research and development for D-X Sunray Oil Co. ... retired in May, completed 38 years in oil refining ... died Sept. 10 ... born 1890 ...

HARRY K. REINOEHL ... (M'13) ... retired, formerly division chief product engineer, International Harvester Co, Fort Wayne, Ind. ... died October 30 ... born 1890 ...

Steps to Better Papers

"THE SAE approach when planning a meeting is to find out what SAE members want to know."

This was said recently by A. O. Willey, SAE Meetings Committee Chairman, in speaking before a program planning group.

Mr. Willey emphasized that "the steps leading to a successful technical program are:

- first, determine the most acute

problems facing SAE members;

- second, locate information concerning the solution of the problems;

- then, formulate a program which presents the available information to the membership."

Some papers may be offered in the areas of top interest; but Mr. Willey stressed that papers should not be presented just because they are available.

SAE

ALBERTA

January 17 . . . Mr. Feldman, Rochester Products Division.—"Fuel Injection." Royal Hotel, Second Street West & Eighth Avenue, Calgary, Alberta, Canada.

BUFFALO

January 21 . . . Chevrolet-Tonawanda Plant Tour. Dinner 7:00 p.m. Meeting 8:00 p.m.

February 5 . . . "Liquid Propane Gas on Wheels." Speaker to be announced. Doud American Legion Post. Dinner 7:00 p.m. Meeting 8:00 p.m.

SAE National Meetings

January 13-17
Annual Meeting and Engineering Display,
The Sheraton-Cadillac
and Statler Hotels,
Detroit, Mich.

March 4-6
Passenger Car, Body
and Materials Meeting,
Sheraton-Cadillac Hotel,
Detroit, Mich.

March 31-April 2
Production Meeting and Forum,
The Drake, Chicago, Ill.

April 8-11
Aeronautic Meeting,
Aeronautic Production Forum,
and Aircraft Engineering Display,
Hotel Commodore, N. Y., N. Y.

June 8-13
Summer Meeting,
Chalfonte-Haddon Hall,
Atlantic City, N. J.

September 8-11
Farm, Construction
and Industry Machinery,
Production Forum
and Engineering Display,
Milwaukee Auditorium,
Milwaukee, Wis.

September 29-October 3
Aeronautic Meeting,
Aircraft Production Forum,
and Engineering Display,
Ambassador, Los Angeles, Calif.

October 20-22
Transportation Meeting,
Lord Baltimore, Hotel,
Baltimore, Md.

October 22-24
Diesel Engine Meeting,
Lord Baltimore Hotel,
Baltimore, Md.

November 5-6
Fuels and Lubricants Meeting,
The Mayo, Tulsa, Okla.

CANADIAN

January 23 . . . E. F. Mareno, International Harvester Co. "Off Highway & Construction Equipment." Royal York Hotel, Toronto, Ont., Canada.

CENTRAL ILLINOIS

January 27 . . . "Earth Satellite." Meeting to be held at the Pere Marquette Hotel Ballroom, Peoria, Ill. Dinner 6:30 p.m. Meeting 7:45 p.m.

CHICAGO

January 27 . . . R. M. Boynton, associate engineer. "Design & Construction of the Mackinac Bridge." Meeting to be presented by the South Bend Division. Bronzewood Room, LaSalle Hotel, South Bend, Ind. Dinner 6:45 p.m. Meeting 8:00 p.m.

February 11 . . . Gregory Flynn, head of mechanical development department, General Motors Research Staff. "Free Piston Engines — Large and Small." Grand Ballroom, Hotel Knickerbocker, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Social Half-Hour 6:15 p.m.

CINCINNATI

January 29 . . . Bruce Crane, Ethyl Corp. "Fuels Today and Fuels of Tomorrow." Netherland Hilton Hotel, Cincinnati. Dinner 6:30 p.m. Meeting 8:00 p.m. Special Guest: 1958 SAE President W. K. Creson.

SECTION MEETINGS

CLEVELAND

January 20 . . . Darl F. Caris, engineer-in-charge, power development section, General Motors Research Staff. "Will the piston Engine Make Good?" Coffee Speaker: 1958 SAE President W. K. Creson.

February 10 . . . Ladies' Night, Higbee's Auditorium, Cleveland, Ohio.

DAYTON

January 28 . . . "Rocket Propulsion Systems." Embers Supper Club, Fairlawn, Ohio. Speaker to be announced. Dinner 7:00 p.m. Meeting 8:00 p.m.

Special Guest: 1958 SAE President W. K. Creson.

KANSAS CITY

January 16 . . . H. T. Dulendorff, service engineer, Echlin Mfg. Co. "Dry Air Filtration." World War II Memorial Building, Linwood and Paseo, Kansas City, Mo. Dinner 7:00 p.m. Meeting 8:00 p.m.

METROPOLITAN

January 16 . . . Everett Morris, senior associate editor, "Motor Boating." "Preview of the New York Motor Boat Show." Roger Smith Hotel, 47th Street and Lexington Ave., New York. Luncheon 12:00 noon. \$3.00 including tip.

January 21 . . . Fred B. Glazier, Curtiss-Wright Corp., Wright Aeronautical Division. "Additives for Aircraft Fuels & Lubricants for Present-Day Aircraft." Kohler's Swiss Chalet Restaurant, Rochelle Park, N. J. Cocktails 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m. Dinner \$3.50 including tip.

February 11 . . . Special Section-Wide Meeting. The meeting will be composed of three afternoon sessions, sponsored Cocktail Hour, and Dinner Meeting. For details see page 112.

MID-CONTINENT

January 13 . . . Aviation Meeting, Tulsa, Oklahoma. Social Hour 6:00 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

MID-MICHIGAN

February 3 . . . Don Graham, chief engineer, Euclid Division, General Motors Corp. "Modern Earth Moving Equipment." Reo Auditorium, Lansing, Mich. Cocktails 6:30 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

Special Feature: Movies. "Truck Operations Across Saudi Arabia" by Arabian-American Oil Co.

MILWAUKEE

February 7 . . . N. M. Reiners, vice president, W. D. Schwab, administrator research laboratory, Cummins Engine Co. "Cummins Turbocharged Diesel Engines." Milwaukee Athletic Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

NORTHERN CALIFORNIA

January 22 . . . Hugh Harvey, aviation technical representative, Shell Oil Co. "High Energy Fuels." Engineers' Club, San Francisco. Dinner 6:30 p.m. Meeting 8:00 p.m.

NORTHWEST

January 18 . . . Wilfred Burkett, McCulloch Motors Corp. "Small 2-Cycle Engines as Used on Chain Saws and Portable Equipment." Stewart Hotel, Seattle, Wash. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Shell Oil Co. film on "Development of the Helicopter."

PHILADELPHIA

February 12 . . . J. R. Rowell, supervisor technical sales data, Cummins Engine Co. "Effect of Dirt on Engines." Engineers' Club Auditorium, 1317 Spruce St., Philadelphia. Dinner 6:30 p.m. Meeting 7:45 p.m.

PITTSBURGH

January 28 . . . J. W. Rowell, Cummins Engine Co. "How Drivers Affect Economy." Mellon Institute Auditorium, Pittsburgh. Dinner 6:00 p.m. Meeting 8:00 p.m.

ST. LOUIS

January 21 . . . Annual Ladies Night Theatre Party. LeChateau, St. Louis. Dinner 7:00 p.m.

January 30 . . . Paul Richard, automotive technologist, E. I. du Pont de Nemours & Co. "Premium Fuels for Premium Cars." Engineers' Club, St. Louis. Meeting 7:00 p.m.

SOUTHERN CALIFORNIA

January 13 . . . Lowell E. Haas, chief engineer, Scott-Atwater Mfg. Corp. "Development of Modern Outboard Motors." Rodger Young Auditorium, Los Angeles. Dinner Meeting.

January 20 . . . Aircraft Panel Meeting. Panel speakers will be Kraftt Ehrike, Convair Astronautics Division; William Besserer, Ramo-Wooldrige Corp.; A. Scott Crossfield, North American Aviation, Inc. "Space Flight." General Petroleum Auditorium, 612 South Flower St., Los Angeles. Meeting 7:30 p.m.

February 10 . . . Aircraft Dinner Meeting. Mr. K. E. Van Every, Douglas Aircraft Co., Inc. "Design Problems of Very High Speed Flight." Rodger Young Auditorium, Los Angeles.

SOUTHERN NEW ENGLAND

January 28 . . . Charles H. Kaman, president, Kaman Aircraft Corp. "General Helicopter Developments." Bradley Field, Windsor Locks, Conn. Dinner 6:45 p.m. Meeting 8:00 p.m.

SPOKANE-INTERMOUNTAIN

January 22 . . . W. B. Burkett, McCulloch Motor Corp. "Two-Cycle Engines as Used on Chain Saws and Other Portable Equipment." Desert Caravan Inn, Spokane. Dinner 6:30 p.m.

February 19 . . . E. J. Barth, chief engineer, Mechanical Transmission Division, Dana Corp. "The New Light-Weight Twelve Speed Transmission." Desert Caravan Inn, Spokane. Dinner 6:30 p.m.

TWIN CITY

January 23 . . . C. A. Nichols, process development group, General Motors Technical Center. "Manufacturing Development as a Staff Function." Hasty Tasty Restaurant, 1433 W. Lake St., Minneapolis. Dinner 7:00 p.m. Meeting 8:00 p.m.

February 12 . . . Neil Blume, chief engineer, Edsel Division, Ford Motor Co. "Engineering the Edsel." Hasty Tasty Restaurant, 1433 W. Lake St., Minneapolis. Dinner 7:00 p.m. Meeting 8:00 p.m.

WASHINGTON

January 21 . . . Allison Division, General Motors Corp. "Automatic Transmissions, Their Application and Use." Occidental Restaurant, Pennsylvania Ave., Washington, D. C. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Slides and discussions to follow.

THE November 13 meeting of the **BUFFALO SECTION** was combined with the **ROCHESTER DIVISION** and embodied a tour of the Delco Products Division of General Motors Corp. in Rochester, N.Y.

The tour included most areas of manufacturing, showing various phases of fabrication of small electrical motors for automotive, industrial and domestic usage. The Section members, divided into small groups, were guided by experienced supervisory personnel . . . allowing good observation and opportunity to ask questions during the course of the tour.

November 20 was the Annual Ladies Night for the Buffalo Section, staged at the Buffalo Trap and Field Club and including buffet dinner and a "Monte Carlo Night."



Above is John Cazier, speaker, at the **CENTRAL ILLINOIS SECTION** October 28 meeting. His presentation, entitled, "Turbocharging Diesel Engines for Earthmoving Equipment," appears as a technical digest on page 117.

November 25 meeting of the Central Illinois Section featured Fred Devaney speaking on "The Taconite Process." Devaney is director of Metallurgy and Research, Pickands Mather & Co.

NOVEMBER 14 meeting of the **TWIN CITY SECTION** featured E. B. Ogden vice-president, Consolidated Freightways, Inc. Ogden presented two papers, "Reconditioning of Vehicle Components; Condition vs. Mileage or Hours," and "Operator's Experience with Recap and Repair of Truck Tires." Prior to the technical session, the Section members toured the maintenance shop and shipping facilities of Consolidated Freightways.

Rambling . . .

THROUGH THE

THAT students are a major consideration in Section planning was pointed up sharply this fall in the many events staged by the Sections with the focus on student interests.

PHILADELPHIA SECTION'S November 13 meeting was Student Activity night, where Coffee Speaker Norman G. Shidle, Editor, SAE Journal, told students that "Writing is a vital tool in any engineer's success kit . . . and that because good writing is based on good thinking, it is perfectly possible for an engineer to write his way to engineering success." Guest speaker at the meeting, Paul H. Richards, Detroit automotive liaison, E. I. du Pont de Nemours & Co., Inc., predicted the automobile design and performance future in his talk entitled, "Cars of the Future." Dinner group at right.



STUDENT night in Canada was staged November 20 with the **CANADIAN SECTION** and students of the University of Toronto. Guest speaker, J. W. Hodgins, chose the subject of "Aspects of Modern Engineering Education," outlining the development and objectives of the newly established engineering center at McMaster University, Hamilton, Ontario. Hodgins is director of engineering studies at the University. The Section took occasion at this meeting to present to E. F. Armstrong, chief engineer of General Motors of Canada, Ltd., and Roy Tompkins, vice-president and managing director of Bettger Industries Ltd., 25-year Certificates of Membership.

WASHINGTON SECTION, on November 19, heard Nevin Bean (right), General Manager, Automotive Transmission Division, Ford Motor Co., speak on the Soviet Machine Age and Automation in Russia. Russian students get paid to go to college, and Russian professors earn more than twice as much as the engineers, the Ford Motor Co. engineer said. Russian students receive up to \$137 a month plus bonuses for good marks. Full professors receive \$1500 a month, and if they are elected to the Russian Academy of Science, they receive \$2700 a month.

In addition, Bean pointed out that Russia has 1.75 million college students, half of whom are engineers. Only the best students go to college and if their marks fall they are put in the Army.

Russian engineers have shown more interest in automation than their American counterparts, Bean reported. Efficiency among workers is increased by an elaborate system of bonuses, and competition is keen among plants and among different departments in plants.

Bean was one of three American engineers who recently toured industrial facilities in the Soviet Union, spending 16 days in Russia.



SECTIONS

METROPOLITAN SECTION meeting of November 14 was held at New York University, and was a Student Activity session. Speaker of the evening was C. Gordon Benett, vice-president of sales, Jaguar Cars North America Corp. His talk was on the value of motor racing and the development of the "D" type Jaguar . . . pointing out the value of racing as a development and field test laboratory. Benett told the audience that improvements in engine and components, developed through racing-type experiments, are passed on to passenger cars . . . a case in point being the disk brake perfected on the racing track and now appearing on sedans. Benett, a 26 year veteran of motor racing, illustrated his presentation with slides, and colored his talk with many amusing anecdotes, and reminiscences.

The second part of the program was a movie on the 1957 Sebring Grand Prix de Endurance . . . showing the race course by diagram and actual air views.

AN outline of what industry expects of a young engineer was presented November 21 at the joint meeting of the **MID-CONTINENT SECTION** and the Student Chapter of Oklahoma State University. Speaker of the meeting was R. S. Frank, assistant chief engineer, Caterpillar Tractor Co., who talked on "The Design Engineer in Industry."

SOUTH BEND DIVISION of the **CHICAGO SECTION** met November 17 with guest speaker William E. Rice, automotive engineer, Clark Equipment Co. "Air Springs as Applied to Commercial Carriers" was the topic of the meeting.

The main reason for using air-spring suspensions on commercial vehicles, Rice pointed out, is that the frequency of vibration remains almost constant, regardless of load. With leaf springs, the cyclic rate of vibration of the spring varies as the load varies.

In addition, the Clark air spring has been designed, he said, to give good lateral stability and sway resistance. The suspension compensates for unloaded and loaded conditions by means of a special hydraulically damped device, which operates only when required. There is a 3-5-sec delay in the leveling operation to limit hunting for level on turns or over bumps.

Seated at the speaker's table were G. H. Stein, president, Ohio Body Co.; P. Ostrander, Clark Equipment Co.; H. W. Fitterling, president, Fitterling Transport Co.; R. L. Handy, South Bend Division chairman, Studebaker - Packard Corp.; W. B. Love, Studebaker - Packard Corp.; L. M. Gray, Clark Equipment Co.; W. E. White, Clark Equipment Co. and technical chairman for the evening.



TWIN CITY SECTION'S

Burnett Iverson, zone service manager, United Motors Service Division, General Motors Corp., received two tickets to the Purdue-Minnesota football game as a reward for getting more applications than any other member of the 1956-57 Section Membership Committee.

The ATLANTA SECTION

sponsored the December 9 meeting of the Georgia Engineering Society, featuring George Kalember and a repeat of his paper on the Lockheed "Jetstar." A technical digest of this presentation appears on page 108 of the December, 1957 issue of the SAE Journal.



BRIGADIER General James B. Knapp

(above) addressed the Wichita Section on December 4 on "Airpower—Today and Tomorrow." Knapp is director of Installations Engineering, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska. A technical digest of this presentation will appear in a future issue of the Journal.

Knapp is the recipient of the Silver Star, Distinguished Flying Cross (1 Oak Leaf Cluster), Air Medal (with 4 Oak Leaf Clusters), and French Croix de Guerre.

PITTSBURGH SECTION'S

television series, (see page 80 of the December, 1957 Journal) has been extended through February 15, 1958. The programs appear every Friday night from 7:30-8:00 pm on Metropolitan Pittsburgh's WQED-TV, excluding December 20.



MEMBERS of the **WESTERN MICHIGAN SECTION** were given rides in the new Cadillac Eldorado Brougham at the November meeting . . . after a presentation by S. L. Milliken, staff engineer for Cadillac Motor Car Division, General Motors Corp. The speaker's topic, "Air Springs for Automobile Suspensions," included a description of several types of air suspensions and detailed discussion of the type adopted by Cadillac. Colored slides were used extensively during the presentation to illustrate the mechanisms and techniques used to maintain the constant level of the vehicle. Appearing above are S. L. Milliken (left), and the meeting Technical Chairman Hosking of Cadillac Motors.

S. M. YOUNG, chief engineer of International Harvester of Canada, Hamilton, Ontario, was recently appointed vice-chairman of the **Canadian Section** to replace D. M. Park, formerly of Wallace Barnes Co., Ltd., Hamilton, who has been transferred to a division of the parent company in Plymouth, Mich. The Canadian Section presented Park with a gift of appreciation at the Section's November meeting.

DECEMBER 3 was Fuels and Lubricants night at the monthly meeting of the **NEW ENGLAND SECTION**. Section members and their guests turned out 100 strong to hear guest speaker Joseph Fahey, and coffee speaker Jonathan Karas.

Fahey, president of PMS, Inc., spoke on "Oil Analysis as Applied to Fleet Maintenance," outlining the history of oil analysis and recounting his numerous experiences with fleet maintenance.

Karas, professor at the University of New Hampshire, returned to the Section meeting, after appearing last month. He presented a short, historically unique, movie showing the first recorded record of Sputnik I. Following the film, Karas spoke on "The Hidden Implications of the Soviet Satellite."

Rambling . . .

THROUGH THE SECTIONS

THE enthusiastic response to the panel type meeting of the opening session of the **NORTHERN CALIFORNIA SECTION** prompted technical chairman Eldon Beagle to select the same format for the Transportation and Maintenance meeting on November 20. The subject, "Advances Toward Alleviating the Shrinking Margins that Beset the Trucking Industry," the panel members, and discussion from the floor, contributed to making a successful evening . . . as well as establishing the panel type meeting as a favorite with Section

members.

Victor Peterson of the San Francisco Municipal Railway acted as moderator, and other panel members were: George U. Brumbaugh, Peterbuilt Motors Co.; John A. Hutchings, Harnischfeger Corp.; Dexter Elam, Rockwell Spring & Axle Co.; Roy K. Walther, Trailmobile Inc.; Lester A. Wilson, Aluminum Co. of America; and Donald W. Behrens, Fuller Mfg. Co.

Each of the panel members made formal presentations, digests of which will appear in a future issue of the Journal.

"**GLASS** and Ceramics as Engineering Materials" was the topic of the November 11 meeting of the **SYRACUSE SECTION**, with guest speaker Gail P. Smith, senior research associate in the Research and Development Division of Corning Glass Works, Corning, N.Y. Using extensively visual aid equipment, Smith discussed and illustrated products which are being made in the division of Corning. His presentation included description of improved methods of strengthening glass through proper tempering; ability of glass to absorb, reflect or transmit various light waves; and the amazing quality of lead oxide glass which absorbs radioactive rays, thus enabling scientists to work under more protected conditions.

Smith also covered calibration of radar equipment by use of 0.001" silica tape which measures speed of reflected wave lengths; improvement of TV color qualities; and oscillation qualities of glass. Industrial lenses and "thirsty" glass were brought up in the discussion which followed.

Pictured below, with some of the demonstration equipment, are, left to right, R. S. Breck, vice-president of the Technology Club where the meeting was held; R. W. Wolfe, Section vice-chairman; E. A. Meyer, Section membership chairman; B. Dawson, president of Technology Club; P. Billings, Section field editor; L. McArthur, Section secretary; G. P. Smith, speaker at the meeting; R. Sturley, Section treasurer; C. B. Spase, 1952-53 Section chairman; and C. L. Frisbie, applicant for SAE membership.



STUDENT branches of INDIANA TECHNICAL COLLEGE and GENERAL MOTORS INSTITUTE

held dinner meetings in November and installed their new officers at that time . . . the Indiana group heard Speaker G. B. Wright, Nordberg Mfg. Co.'s district manager for the Heavy Machinery Division discuss Nordberg diesels . . . General Motors Institute's meeting includes movies, slides, and a talk on Proving Ground activities

by K. A. Stonex, assistant director of General Motors Corp.'s Proving Ground. Appearing at right is Stonex.



NOVEMBER meeting of the ST. LOUIS SECTION was an international one . . . with representation from opposite sides of the globe in attendance. The meeting, sponsored by Section Diesel Activity Committee, featured Charles J. Wilhite, manager of Field Service for Cummins Engine Co., Inc., speaking on "The Case for the Diesel Engine."

International visitors included D. Eakins, superintendent of maintenance, and K. T. Hall, automotive equipment engineer, both of Melbourne Tramways Ltd. of Melbourne, Australia. Eakins and Hall were guests of the St. Louis Public Service Co., and are visiting this country to study methods of maintenance operation and control. From London, England, were Messrs. J. Hollis and Atkinson, both of Shell Petroleum Co., Ltd., guests of the Shell Oil Co. of Wood River, Ill. Atkinson is a research engineer and Hollis working with product application.

Appearing inspecting a bus powerplant, left to right, are: W. E. Williamson, superintendent, St. Louis Public Service Co., and Section chairman; Kenneth Hall, automotive engineer, Melbourne Tramways Ltd.; David Eakins, chief engineer, Melbourne Tramways Ltd.; A. H. Hollerbach, superintendent of railway and plant maintenance, St. Louis Public Service Co.



THE November meeting of the BALTIMORE SECTION proved to be a series of "firsts" for the Section members . . . it was the first technical meeting of the season; first meeting of the newly organized Diesel Activity of the Section; and the first night that the Section members wore new membership badges. Speakers were Max Berchtold, in charge of research and development for the Special Products Division of I-T-E Circuit Breaker Co., and Frederick W. Lohmann, vice-president of Diesel Energy Corp., subsidiary of Kloeckner-Humboldt-Dietz Co. of Cologne, Germany. Berchtold's presentation was on The Compress Supercharger, and Lohmann's on air cooled diesel engines.

The Section's new membership badges (above) are a plastic square with metal clip for convenient attaching to coat or shirt. Name cards are inserted into the badge . . . white cards are used for members, and blue cards for officers and members of the Section Governing Board. Guests and visiting members still utilize the standard pocket insert. It is believed that this system will make it easier to identify visiting members . . . as well as help local members know their Governing Board.

MOHAWK-HUDSON SECTION members heard 1957 SAE President W. Paul Eddy at their meeting on November 19. Eddy, speaking on the conversion of piston engines to aircraft turbojet and turboprop engines, was introduced by Harold D. Kelsey, manager of engineering, gas turbine department, General Electric Co.

Also during the November meeting, William Waddell was presented with a 25-year Certificate of Membership. Appearing in the photograph at the right with W. Paul Eddy (middle) are, Harold D. Kelsey (left), and Mohawk-Hudson Section Chairman P. E. Kezer (right).



Rambling . . .

THROUGH THE SECTIONS



THE use of plastics in automobiles, now averaging 19 lbs per car, will double by 1960 according to Raymond F. Boyer of Dow Chemical Co. Boyer, speaking to the **MID-MICHIGAN SECTION**, supported this contention by describing some promising new plastic materials and techniques.

The new plastic materials discussed by Boyer included: Tyril, a styrene copolymer; Lexan, a polycarbonate developed by General Electric Co.; a polyurethane foam; and a new polyethylene foam. (A technical digest of this paper will appear in a future issue of the Journal.) Boyer, director of plastics research, Dow Chemical Co., left, and Philip B. Zeigler, Mid-Michigan Section chairman examine samples of the new plastics discussed in Boyer's presentation in the above photograph.

"TODAY we have cars of tomorrow on the roads of yesterday, but a new federal highway system is designed to catch up with the past." So stated Ellis L. Armstrong, director of highways for Utah before a joint meeting of the **SALT LAKE CITY SECTION** of SAE and ASME on September 9. In commenting on the magnitude of projected federal highway program, he noted that over 750,000 parcels of land must be secured for the approximate 41,000 miles of right-of-way at a cost of close to \$6 billion. The cost of the total project approaches \$52 billion; earth moving will account for approximately 30% of the cost.

The highway will pass through or near the capitol cities of 42 states; and cross one-third of all counties; and carry 20% of all highway traffic, the speaker noted. These roads will be built in a span of 13 years, and are planned 20 years in advance for the traffic of 1975.

Armstrong listed benefits of the

projected new highways as: greater safety through a one-third reduction of accidents; faster and more efficient traffic movement; improved national economy through improved traffic movement; and an improved system of highways for national defense.

Utah's Governor George Dewey Clyde was a special guest at the **SALT LAKE CITY GROUP** meeting, and introduced the main speaker of the evening. Seated, (at right), left to right, Governor Clyde, and Meeting Speaker Ellis L. Armstrong. Standing left to right, Salt Lake Group Chairman J. P. Bywater, and W. B. Littreal, Section field editor.



SHOWN below are the members of the **DETROIT SECTION** Junior Activity Executive Committee. These people are responsible for the planning, organization and operation of the technical meetings and field trips sponsored by the Detroit Section Junior Activity in 1957. Other activities include advising Detroit area student branches and maintaining Junior membership interest.

The 1957 program included a field trip through the Ford test track and Research Center of Dearborn in September, and in November a three speaker panel discussion of the 1958 passenger car suspensions entitled "Riding on Air." Technical meetings are also scheduled for January and March . . . an April field trip will round out the year's program.

Standing from left to right are: J. R. David, Pure Oil Company, Reception Committee chairman; R. F. Jenson, American Motors Corporation, treasurer and vice-chairman of the Executive Committee; R. L. Aldrich, Dodge Division, Chrysler Corporation, Student Activity Committee chairman; D. F. Kopka, DeSoto Division, Chrysler Corporation, Meetings Attendance Committee chairman; D. A. Jones, Hannifin Corporation, secretary; R. J. Stark, Eaton Manufacturing Company, Membership Committee chairman; D. A. Kinker, Engine Division, Chrysler Corporation, Meetings Operation Committee chairman; W. E. McCollough, Holley Carburetor Company, Preprint Committee chairman.

Seated left to right are: R. L. Courtney, Ethyl Corporation, Meetings Publicity Committee chairman; Miss Edith McCoy, Assistant Secretary of the Detroit Section SAE; W. E. Oliver, Dodge Division, Chrysler Corporation, assistant vice-chairman of the Junior Activity; H. C. MacDonald, Mercury Division, Ford Motor Company, vice-chairman of the Junior Activity; H. P. Freers, Mercury Division, Ford Motor Company, Program Committee chairman.



DURING the TEXAS GULF COAST'S November meeting on Vehicle Selection—a panel-type session—there was considerable interest in the following questions: (1) Are foreign vehicles making inroads in American fleets? The panel agreed that foreign vehicles are gradually replacing many of the heavy, American vehicles, especially in city pickup-and-delivery services. Fleet operators and leasers are becoming more concerned about economy, which the small, foreign vehicle with low horsepower provides. The panel also pointed out that formerly it was not desirable to use foreign vehicles because parts and trained mechanics were scarce; however these problems are now being alleviated. The need for a small, American-made, city pick-up-and-delivery vehicle that can compete with the foreign counterpart, was discussed by the group.

(2) What are some fundamental factors that should be considered when buying vehicles? The panel's answer was—get the truck that is engineered for the job . . . any customer should consider the following: payload to be carried; desired speed; type of body to be installed on the chassis; availability of desired fuel; terrain to be traveled; climate in operating areas; power units to be added to the chassis; availability of service facilities and parts; road clearance; power train; cooling system; tires; and especially, economical operation.

(3) How important is a comfortable truck-cab? Use is the determining factor here, the panel pointed out . . . whether the function will be city pick-up-and-delivery work, or over-the-

road, long-haul work. A standard cab is satisfactory for the former, the panel concluded, and the latter calls for a comfortable cab with foam rubber cushioning, power steering, air or hydraulic operated clutches, tinted glass, air conditioning and the like. The panel stated that a comfortable driver is a smoother, more economical driver.

(4) How should an over-the-road truck be operated before it is replaced? It was the consensus of the panel that 60,000- to 80,000-lb gvw vehicles should be operated eight years or one million miles . . . 50,000- to 60,000-lb gvw vehicles should be replaced after 8 years or when operated one-half million miles. However, once a year, each vehicle should be completely overhauled, repainted, and the like. It was brought out that large, over-the-road carriers recently were considered in an 8-year replacement study—half the fleet was operated eight years or one million miles and replaced; the other half of the fleet replaced every two years. The result was that the cost of each group was the same.



1957 SAE President W. Paul Eddy is greeted by Arthur N. W. Andrews, vice-chairman of the Hawaii Island area for the **HAWAII SECTION**, during Eddy's recent trip to the islands. Immediately following the SAE National Aeronautic Meeting in Los Angeles, Eddy and his wife left to spend from October 6 to 13 visiting the Hawaiian Islands, starting in Honolulu and traveling to Maui and Hilo.

The 1957 President met with SAE members in Honolulu on October 8; with SAE's on Maui on October 9, and with the engineers in Hilo on October 10.

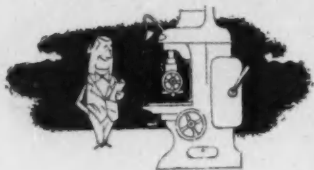
TEXAS GULF COAST SECTION'S Governing Board gathers before the November 15 meeting. Left to right are: D. W. Wing, Section vice-chairman, Truck and Bus; R. C. Sullivan, Koenig Iron Works, Inc.; D. E. Smith, Section Student Committee chairman; E. J. Strawn, Shell Oil Co.; W. B. Tilden, Section vice-chairman; R. F. Wilson, Section chairman; A. C. Zugar, Cummins Sales and Service Inc.; B. Fortenberry, Section vice-chairman, Transportation and Maintenance; E. W. Rentz, Jr., manager of SAE West Coast branch office; E. L. Asch, Section treasurer; J. W. Kelly, Jr., Membership Committee chairman; B. F. Denny, Schlumberger Well Surveying Corp.



ATTEND THE 1958 ASTE TOOL SHOW

CONVENTION CENTER
PHILADELPHIA MAY 1-8

SEE all the very latest advances and improvements in more than thirty major categories of industrial products.



ATTEND top-level conferences, conducted by recognized authorities on the newest production techniques and developments.



MEET and exchange ideas with management, engineering, production, sales people from the nation's leading industrial concerns.



INSPECT the modern equipment and up-to-the minute manufacturing methods being utilized in booming Delaware Valley plants.



Rambling . . .

THROUGH THE SECTIONS

continued



J. C. JOHNSON appears addressing the **SOUTHERN NEW ENGLAND SECTION** on "Watt Muscles in the Modern Automobile," at the November 13 meeting. Props included in the presentation included two slide projectors and screens, a blackboard, and a hard-top convertible.

SPECIAL Section-wide meeting for the **METROPOLITAN SECTION** will be held Feb. 11, at the Henry Hudson Hotel, 57th St. & Ninth Ave., N.Y.

The meeting will be composed of Three Afternoon Sessions, Sponsored Cocktail Hour, and Dinner Meeting:

Afternoon Sessions will start at 2:30 P.M.

Session #1—Sponsored by the Passenger Car & Body and T & M Activities.

Subject: "Dragnet for Defects" (Trucks & Pass. Cars)

Panel: E. Gray, Asst. Chief Engr., Chevrolet Motor Div., GMC—"Filed Testing"

H. M. Bevans, Chief Engr., Vehicle Testing, Chrysler Corp.—"Proving Ground Operations"

Carl T. Doman, Nat'l Service Mgr., Ford Div., Ford Motor Co.—"Quality Control"

Session #2—Sponsored by the Air Transport and Aeronautics Activities.

Subject: "Management's Role in Meeting the Future of the Aircraft Industry"

Speaker: Edward Stone, Chief Economist, Glen L. Martin Co., Baltimore, Md.

Subject: "The New CAB Performance Regulations As They Apply to Air Transport"

Speaker: American Airline Representative

Session #3—Sponsored by the Fuels & Lubricants and Diesel Engine Activities.

Subject: "Diet, Medication or Surgery"

Panel: Grover Wilson, Ethyl Corp.

"The Way Fuels Can Assist in Maintaining and Improving the Performance of Future High Speed Compression Ignition Engines"

Len Raymond, Socony or Representative of Lubrizol

"The Role of Lubrication in High Performance Diesels—Series?"

Bruno Loeffler, Mack Trucks, Inc.

"Requirements of Future Diesel Engines for Better Fuels and Lubricants and the Extent to Which Engine Designers Can Meet These Requirements"

Sponsored Cocktail Hour: 5:30 P.M.

Dinner: 6:30 P.M.—1958 SAE President William Creson, will be Guest Speaker.

Principal Speaker—to be announced.

Dinner: \$6.00. Registration fee for non-members: \$1.00

A brief summary of the Afternoon Sessions will be given.

**DURING THE 1957
MODEL YEAR
ALONE . . .**

**the
automotive
industry
used**



**MORE THAN 10,000,000
HYATT TAPERED ROLLER BEARINGS!**

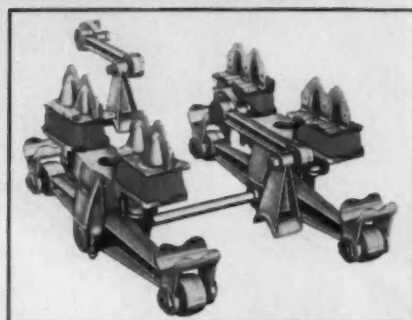
*Nearly half of all
American cars and
trucks built today
have HYATT Hy-Roll
Tapered Bearings*

Yes, America's recognized leader in the cylindrical bearing field is also a big, BIG factor in the *tapered* roller bearing business!

Today HYATT's new electronically-controlled production lines are turning out *millions* of tapered bearings with greater uniformity than ever before achieved in quantity production. These advanced manufacturing techniques, plus traditional HYATT craftsmanship, assure longer, smoother, more dependable performance in your toughest automotive applications. Hyatt Bearings Division, General Motors Corporation, Harrison, N.J.; Pittsburgh; Detroit; Chicago; Oakland, California.

HYATT **HY-ROLL BEARINGS**
FOR CARS AND TRUCKS





The unique design of the "load cushion" accounts for smooth, even rides in the full range of loads, empty to full. Enjay Butyl Rubber (in red) made it possible.

ENJAY BUTYL **"LOAD CUSHION"**

replaces steel springs in big Tractor Trailers

The "load cushion" is an important innovation in tandem suspension. Developed by the Hendrickson Mfg. Company, it is made of Enjay Butyl and replaces steel leaf springs. Utilizing the great strength and impact resistance of Enjay Butyl, the "load cushion" gives the ultimate in a soft, easy ride within the complete range of loading, from empty to full. Besides giving a smoother, steadier ride, it increases tire mileage, reduces weight and significantly reduces wear and tear on equipment.

Enjay Butyl has proved to be the answer to problems in many fields of industry. It may well be able to cut costs and improve the performance of *your* product. Low-priced and immediately available, Enjay Butyl may be obtained in non-staining grades for white and light-colored applications. Get all the facts by contacting the Enjay Company. Complete laboratory facilities and technical assistance are at your service.



Pioneer in Petrochemicals

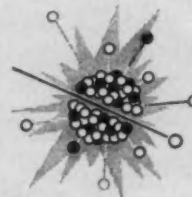
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Enjay Butyl is the super-durable rubber with outstanding resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

NUCLEAR NEWS NOTES

A feature of the SAE Nuclear Energy Advisory Committee



How Atomic Energy Aids the Metallurgist

Reported by

A. A. Kucher

member, SAE Nuclear Energy
Advisory Committee

ATOMIC energy is aiding the efforts of the metallurgist—and therefore the automotive engineer—in two ways:

- By improving our fundamental knowledge of metals and their behavior.
- By improving various products and processes, particularly with the aid of radioisotopes and reactor irradiation.

Understanding Metals and Their Behavior


Rapid strides have been made in understanding the plastic behavior of metals as a result of acceptance of the concept of dislocations in crystals as one important type of imperfection. Experimental determination of the interactions of edge and screw dislocations, vacancies, and interstitial and impurity atoms has demanded a large portion of the recent efforts of physical metallurgists and solid state physicists. Progress in this area has been greatly aided by the unique circumstances resulting from neutron bombardment of metals and alloys at low temperatures to produce imperfections in the crystal structure.

Rearrangement and interaction of these imperfections can be induced by subsequent controlled annealing and studied by measuring structure sensitive physical property variations, thereby providing information about metal structure changes which cannot be obtained in any other known manner. Fundamental studies of this kind provide a basis of metallurgical understanding which can lead to the design of alloys to provide higher strength, better fabricability, and improved physical properties.

Fundamental knowledge of the aqueous corrosion of iron is being acquired through the use of radioactive technetium compounds. The tremendous sensitivity of the tracer technique has permitted the successful performance of very elegant and decisive experiments.

Product and Process Improvement
Closer to product application and

Continued on page 117



AUTOPULSE
ELECTRIC
FUEL PUMPS

**A 30-YEAR
RECORD OF
DEPENDABILITY**

Hundreds of thousands of gasoline powered vehicles have been Autopulse-equipped at the owners' own expense. They spent their money just to get the greater dependability and reliability provided by the Autopulse electric fuel pump.

Positive starting at any temperature . . . elimination of vapor lock . . . efficiency at any altitude . . . these are three of the reasons why users switched to Autopulse.

Why not consider Autopulse as standard equipment?



Electric **AUTOPULSE** Division

WALBRO CORPORATION

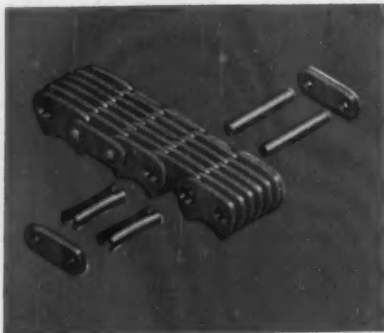
Ludington • Michigan



More than 80,000,000 durable Morse Timing Chains have been used by the auto industry. Now specified as original equipment for 3 out

of 4 passenger cars, Morse Timing Chains give car owners steady, reliable service—operate quietly and smoothly, with positive timing.

It's almost unanimous: 3 out of 4 1958 cars use Morse Timing Chain!



This new Morse Timing Chain, above, designed to meet the needs of higher-horsepower 1958 cars, features spring-bushing joint construction for longer service, smoother and quieter operation. The new bushing cuts joint vibration by reducing tendency to "whip," provides for take-up of slack, and serves as a damping device to minimize noise. Ask for Catalog C60-51.

The reason is simple: Precision-built Morse Timing Chain assures car owners of trouble-free timing for extra thousands of miles.

It's been performance-proved by more than 80,000,000 Morse Timing Chain installations on cars, trucks, and buses.

It pays to contact Morse on all your timing chain problems—original equipment or replacement. For complete information or engineering help, phone, wire, or write **MORSE CHAIN COMPANY, DETROIT, MICHIGAN; ITHACA, NEW YORK**. Export Sales: Borg-Warner International, Chicago 3, Illinois.

SERVING THE AUTOMOTIVE
INDUSTRY FOR OVER 55 YEARS

MORSE



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Nuclear News

Notes . . . con't. from p. 115

process improvement we note a number of developments utilizing radioactive isotopes:

- Wear of cutting tools can be followed very closely by radioactive counting of swarf produced by the tool after it has been irradiated in a reactor.

- Piston-ring and bearing wear in engines is easily followed by observing the radioactivity transferred to the lubricating oil by the particles removed from the activated compound.

- Pinholes in tinplate are identified by flooding the plate surface with a cobalt-60 chloride solution, washing, then counting. The radioactive cobalt is deposited by exchange with the exposed iron surface in the pinhole. Plating procedures can thus be studied.

- Autoradiographic methods are being used to improve continuous casting of steel and aluminum. The liquid-solid boundary, the nature and extent of segregation, and turbulence in the molten zone can be observed photographically after adding a radioactive element, freezing, and sectioning the billet. The increasing use of radiation thickness gaging in sheet-metal production insures a more uniform product, with attendant economies both in the mill and in final fabrication, because of reduced scrap loss and down time in stamping operations.

- Radioactive isotopes for radiographic examination of components often have definite advantages in portability and cost over standard X-ray equipment.

The last two applications were discussed in the September, 1957, SAE Journal Nuclear News Notes in relation to the increased supply of radioisotopes.

Finally, a host of benefits to the automotive field is accruing from the solution of metallurgical problems in the area of reactor technology. Improved welding techniques used in fuel element and component fabrication, development of special stainless steels and zirconium alloys for reactor core applications, and better understanding of the causes of stress corrosion may be mentioned as examples.

Automotive and aeronautical engineers look to the promise and potential of ultra-high-strength steels, improved titanium, aluminum and magnesium alloys, and special processing methods, such as electron beam melting and vacuum casting, which will solve many of their problems.

Turbocharging Diesels For Earthmoving Machines

Based on talk by

JOHN CAZIER

AiResearch Industrial Division, Garret, Corp.
(As reported by R. D. Chandler, SAE Central
Illinois Section Field Editor)

THE trend to turbocharging diesel engines for earthmoving equipment is new, but of overwhelming proportions.

The first real production release of a turbocharged machine was made at the end of 1954. Today, three years later, practically all of the leading manufacturers of earthmoving equipment are furnishing turbocharged engines. They have "turbocharged" for the same reasons—to develop more power, more efficiency, and for less money from the same size powerplant. The turbocharged engine, being a combination of a gas turbine engine and a diesel engine, is indeed a true compound powerplant.

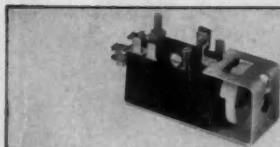
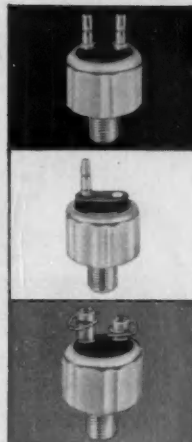
Turbocharging an engine is sim-

FASCO AUTOMOTIVE ELECTRICAL PRODUCTS

designed for today's
needs with tomorrow's
requirements in mind

Fasco products have been serving America's Automobile Industry for over 30 years, and serving them well. Today, as in the past, Fasco is responding to the ever-increasing demand with products designed and built to meet exacting industry needs . . . and will continue to respond with "look-ahead" designs to meet the challenges of the future!

HYDRAULIC
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ply another means of supercharging. The prime virtue of the turbocharger is that no crankshaft power is required to drive it. Ordinary superchargers, such as the Roots-blower type, are restricted to the 20-40% power increase bracket because they are crankshaft-driven, and thus place a parasitic load on the engine. Such is not the case with the turbosupercharger because its compressor is driven by an exhaust-gas-powered turbine wheel, and because there are no mechanical drive connections to the engine.

The turbocharger has a centrifugal compressor composed of two elements, the impeller (or rotating part) and the diffuser. All of the work done on the air is performed by the impeller, which produces about half the pressure rise. The diffuser converts the velocity head of the air into the remainder of the pressure rise. Diffusers may or may not have vanes, depending on the overall design of the turbocharger.

Turbochargers are inherently high-speed machines. Very high rotational speeds of the impeller are quite common. Impeller tip speeds are in the neighborhood of 1100-1400 fps. A turbocharged engine developing 400 hp will have a 6-in. compressor operating at 48,000 rpm, while a 100-hp engine will have a 3-in. compressor operating at 90,000 rpm. A good turbocharger offers a more efficient compressor than is available with crankshaft-driven superchargers.

Comparatively large-diameter engine exhaust stacks are required for turbocharged engines. A large-diameter exhaust stack is the "trade-mark" of an earthmoving machine powered by a turbocharged engine.

Because a good turbocharger is more efficient in terms of compressor efficiency, turbine efficiency, and mechanical efficiency, the exhaust manifold pressure and temperature can be lower for a given degree of supercharge, thus increasing the overall efficiency of the turbocharged engine.

How an Oil Company Picks a Fuel Additive

Based on paper by

WALTER G. AINSLEY

Sinclair Research Laboratories, Inc.

(Presented before SAE Atlanta Section)

THE first step in finding the best possible method of alleviating the detrimental effects of combustion-chamber deposits is to study all the components of the fuel. Since this never gives a complete solution, a search is made for deposit-modifiers that are effective as additives in low concentrations.

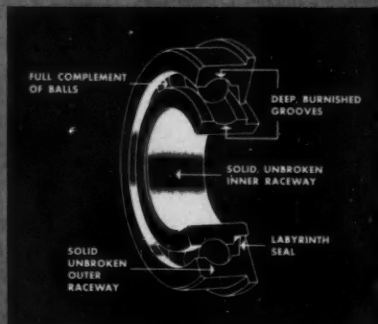
The problem then is to find the additive that will meet the following re-

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Note this unusual construction (patents pending):

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- Both raceways are deep carburized and hardened.
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quirements:

1. Reduce the incidence of surface-ignition.
 2. Reduce spark-plug fouling.
 3. Cause no increase in engine octane requirements.
 4. Cause no reduction in road octane ratings of a fuel.
 5. Be free from detrimental effects on such gasoline properties as gum, oxidation stability, and corrosiveness.
 6. Have suitable solubility in gasoline over a wide range of temperatures, and be nonextractable by water.
 7. Cause no increase in engine wear.
- At the start of an evaluation of

probable compounds, a single-cylinder engine is used for screening. An ionization gap located in the combustion chamber is connected to an electronic counter, which records each time a flame passes this gap. A timer is placed in the circuit so that the counter is cut off before the normal flame front from the spark-plug ignition can reach the ionization gap. This gives a total count of the number of preignitions occurring over a period of 25 hr. By comparing total count and the slope of the curve from which we obtain the rate increase with deposits on a base fuel with the same information on that

fuel plus an additive, it is possible to pick out those compounds which show the most promise.

The best of these compounds are then tested for their effect on laboratory octane number, on gum, on oxidation stability, and on corrosion. It must not settle out over a wide temperature range and must not be affected by water.

Those additives that live through this screening are tested in multicylinder engines. An engine such as the 1957 Cadillac is run on an automatic cycle. Power output is determined at the start of the test. At each 50 hr all plugs are replaced and a power reading obtained. Then each test plug is replaced successively in the same cylinder in which it was used. If a power loss, indicating misfiring, is noted it is replaced with a new plug. The bad plugs are recorded and saved for visual study.

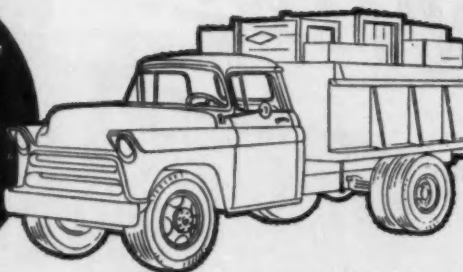
When a compound gets to this stage, we begin to look critically at its availability, cost, and ease of handling. If it still looks good it is put in several modern engines on the dynamometer under severe operating conditions to check wear, effect on valves, and many other properties. Then a road test program is set up using the laboratory fleet, checking the cars on the chassis dynamometer at the end of each 500 miles until 10,000 miles have accumulated. The engines are then disassembled and all parts observed.

When an additive has survived this program, we feel confident of its quality, but it is usually tried in a larger group of employees' cars for a final check before it is used in gasoline which goes to the customer.

To Order Paper No. S32 . . .

on which this article is based, see p. 5.

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Antarctica Affords Automotive Test Ground

Based on talk by

HENRY F. BIRKENHAUER

John Carroll University

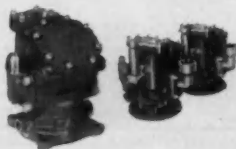
(Presented before SAE Cleveland Section)

ENGINEERS will get extensive information on automotive vehicle performance from the exploration of Antarctica incident to the International Geophysical Year. Caterpillar tractors, weasels, snocats, and Canadian rats are the modes of transportation. The traverses will be led by a light-weight vehicle extending five dishpans before it to sound for crevasses. Wagnigans will carry bedding, cooking utensils, and supplies. The entire traverse party will depend completely on gasoline or diesel fuel. Actually, Antarctica could not be seen, studied, and dissected by other than coastwise sailing and a few isolated air drops were it not for the gasoline and diesel engine.

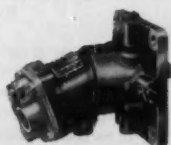


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Highest overall efficiency and minimum heat rejection of the pumps . . . and exceptional dependability of all components were decisive factors in the selection of Vickers Hydraulics for the powerful Republic F-105 Thunderchief.

The principal Vickers components in the F-105 are illustrated at the left. These, and all other Vickers aero hydraulic units and systems are tailored to airborne needs—light, compact, durable, dependable and efficient. Also, back of all Vickers products is a well organized and factory-staffed service organization.

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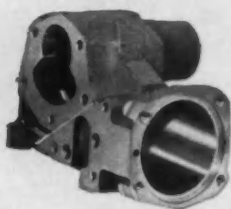


ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Why MICROHONING

Is Final Stock Removal Process For Interrupted and Blind-End Bores

To secure low-cost, final stock removal, that generates accuracy and functional surface characteristics in a variety of bore conditions, a leading manufacturer of power steering assemblies uses Microhoning. Here are details concerning types of bores and stock removal results obtained by using Micromatic "Know How"—



STEERING GEAR HOUSING—Microhoning consistently corrects cumulative inaccuracies of preceding operations—reduces scrap—permits faster boring—cuts boring tool sharpenings—lowers down-time and tool costs.

Material: Soft Malleable Iron
Bore: 3.125"D x 6.93"L
(Ported bore with 1/4" relief at blind end)

Stock Removal: .002"
Finish: 50 Microinches RMS
Microhoning Cycle: 18 sec.
Preceding Operation: Boring



PISTON RACK—Microhoning answers the need for a final stock removal process that generates a controlled surface finish in the bore of this leaded steel part. Microhoned surface (cross hatch) prevents oil leakage and holds to a minimum the wear of seal that operates in the bore.

Material: Leaded Steel (Rockwell 62 "C")
Bore: .875"D x 3"L
Stock Removal: .005"

Finish: 20 Microinches RMS
Microhoning Cycle: 20 sec.
Preceding Operation: Boring and H.T.



VALVE HOUSING—Microhoning consistently holds size and geometric accuracy—meets stringent surface requirements—assures alignment of four lands in bore. Thus, there is no leakage of oil around control valve which is selectively fitted to its housing.

Material: Cast Iron
Bore: .770"D x 2.18"L
(Interrupted)
Stock Removal: .0025"
Tolerances: Size .0005"

Roundness: .0001"
Straightness: .0001"
Finish: 10 Microinches RMS
Microhoning Cycle: 12 sec.
Preceding Operation: Boring

The principles and application of Microhoning are explained in a 30-minute, 16mm, sound movie, "Progress in Precision" . . . available at your request.

- ☐ Please send me "Progress in Precision" in time for showing on _____ (date).
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- ☐ Please send Microhoning literature and case histories.

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Fins Improve Automobile Stability

Based on paper by

V. M. EXNER

Chrysler Corp.

(Presented before SAE Detroit Section)

THE only way to stabilize a car without destroying the good wind-resistance properties inherent in a modified "tear-drop" design is to use fins.

Tests on cars with dart- or wedge-shaped bodies have proved that—with upswept fins—road-holding stability is improved. Also, steering correction may be reduced by as much as 20% in strong cross-winds at normal highway driving speeds.

Addition of rear fins, the tests indi-

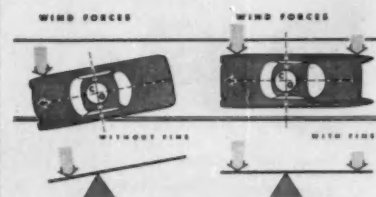


Fig. 1—Tail fins balance wind forces about car's center of gravity.

cate, equalizes the forces about the pivot resulting in less tendency of the wind to turn the car off its course (Fig. 1). With the fins, the rear of the car presents a larger surface, directing the side-wind so that its force is better balanced about the car's center of gravity, which acts as the pivot point. The side wind, in other words, is made to compensate for its own ill effects.

To Order Paper No. S17 . . . on which this article is based, see p. 5

Power and Balance Are Key to Good Braking

Based on paper by

H. T. SEALE

H. T. Seale, Inc.

(Presented before SAE Oregon Section)

DELIVER the braking power as rapidly as possible, and then compensate for any unbalance through use of available leverages. This is the cardinal rule laid down for good truck-trailer brakes. It applies both to design and maintenance of the vehicle.

Designers must provide satisfactory components, such as reservoirs, brake drums and linings, tires, brake chambers, and linkages. Operators then must make sure that balanced, fast power is delivered to the brakes.

Operators can hold up their end of the rule with three simple steps: vis-

ual inspection, adjusting linkages, and checking with a duplex gage.

The major problem is delivery of air from the reservoir to the brake chambers. Here, the duplex gage points the finger at the trouble. The gage reads the pressure at any two points and compares buildup times. The come-in time of different axles can be compared and delays in pressure buildup time across valves and plumbing can be spotted with the gage. Once the air pressure is delivered full and fast to the brake chambers, the setting of slack adjusters and linkages will balance the brakes. Finally, the brake linings and tires can be visually inspected to insure good performance.

Here are some examples of plumbing that have caused poor braking:

- A trailer valve required 18 psi to open, so the tractor was breaking drums trying to stop the combination. An exchange trailer valve solved the problem.

- Three 60-40 dividing valves were connected between one trailer and three tractor axles. The valve return springs took 4 psi to open. For a 30-psi application, the trailer brakes netted 14 psi, the third tractor axle netted 3.2 psi, and the first and second tractor axles netted zero. Replacing the 60-40 valves with a relay valve to bring the tractor in on time restored good braking.

- A wrecked full trailer was found to have been using only two ports of the trailer valve on a full trailer. One port supplied one brake chamber while the other supplied the remaining three chambers.

- An obstruction in the trailer line was wearing out the tractor brakes. A tube had been cut, but not reamed. When corrected, brakes returned to normal.

To Order Paper No. S2 . . .
on which this article is based, see p. 5

Automatic Maintenance in Aircraft Promotes Safety

Based on paper by

ROMIE A. TAYLOR

Convair

VERIFYING correct component operation, isolating faulty operation, and warning of impending failure are primary functions of automatic maintenance devices used in aircraft.

Sensing devices are installed in the aircraft. Their voltage output is fed into a programmer during ground checks. A simple direct reading tells if maintenance is required.

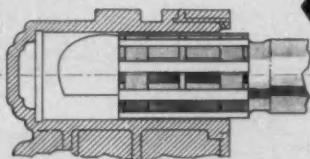
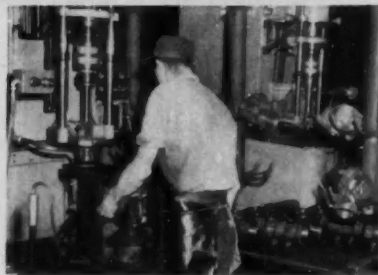
For economy and light aircraft weight, only components critical to the safety and main function of the airplane should be automatically maintained. In all cases, the maintenance device should fail safe and not affect the component.

To Order Paper No. 208 . . .
on which this article is based, see p. 5

How MICROHONING

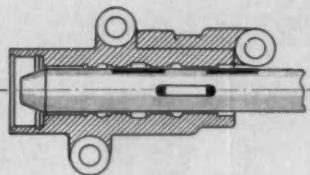
Cuts Costs—Generates Accuracy—Speeds Production of Interrupted, Blind-End Bores

Shown are two Microhoning machines that are used in the plant of a leading manufacturer of automotive power steering assemblies. Machines are equipped with automatic stone feed and stonewear compensating mechanisms, and automatic sizing controls. A two-position rotary fixture is interlocked with machine controls for fully automatic index cycle. The following applications tell more of the "how".



STEERING GEAR HOUSING—In Microhoning the ported, blind-end bore of steering gear housing a nine-stone tool is used. At least six of nine stones are in contact with bore surface when tool passes over irregularly shaped port. Removing .002" of stock from 3.125"D x 6.93"L bore in 18 seconds, Microhoning generates final accuracies and a controlled finish of 50 micro-inches as specified.

PISTON RACK—In 20 seconds, Microhoning removes .005" of stock from .875"D x 3"L open end leaded steel bore of piston rack. Self-sharpening abrasives assure a consistent generation of specified surface finish of 20 microinches.



VALVE HOUSING—Microhoning tool used for final stock removal in bore of valve housing has one bank of stones and two banks of plastic guides—three stones or guides in each bank. Guides act as tool pilots and stabilizers in interrupted bore—prevent overcutting at edges of lands—assure straight bore by keeping tool aligned. Self-dressing abrasives consistently generate geometric accuracy of .0001" and surface finish of 10 microinches.

Microhoning economically removes stock—corrects cumulative inaccuracies of preceding operations—reduces scrap—permits faster boring—lowers machine tool downtime and maintenance to cut costs and speed production.

Send Coupon for Complete Information

Learn how Microhoning will give efficient stock removal, closer tolerances, accurate alignment and functional surfaces.

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Light Alloys Impractical For Passenger-Car Bodies

Based on paper by

L. M. FORBUSH

General Motors Corp.

THE use of light alloys for passenger-car bodies appears to be impractical, at present, for the following reasons:

1. **Lack of stiffness.** Pure aluminum

has a modulus of elasticity of 10×10^6 psi; magnesium 6.5×10^6 psi; and titanium 16.8×10^6 psi. Therefore, three materials which might be used for weight reduction of passenger-car bodies provide only one-third, one-fifth, and a little better than one-half the stiffness provided by steel for the same section. Obviously, the use of these materials for highly stressed members simply increases the difficulty of maintaining suitable stiffness.

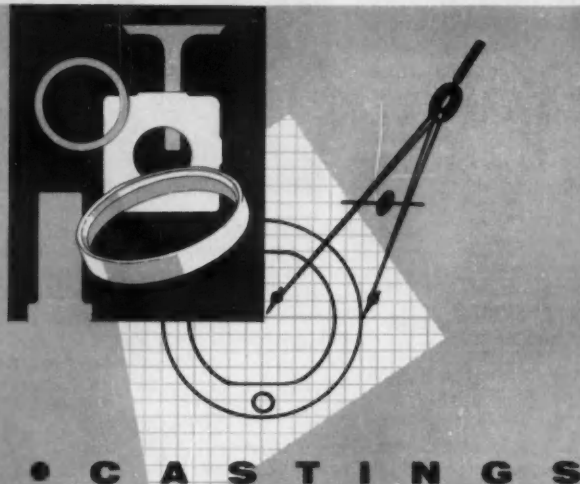
2. **Manufacturing economics.** Both

magnesium sheet and titanium sheet must be preheated to a temperature held within a narrow range before forming. They must be formed in heated dies and must be stress-relieved by carefully controlled heat treatment before trimming. Seams and similar continuous joints must be made with heliarc welding and, on thin sections, the inert gas must be directed at both sides of the weld.

Aluminum is easier to form but presents similar problems in joining sections together.

In automotive production, an enormous amount of money is invested in tooling. If some parts continue to be made of steel, the existing tool investment for steel parts of the car will only be slightly reduced. The new tools required for the new materials, in addition to being expensive, will require extended floor space, will require a revision of parts flow, and thus ultimately will require a considerable increase in total capital invested in the manufacturing process.

To Order Paper No. S 26 . . . on which this article is based, see p. 5



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Procurement Can Reduce Future Maintenance Costs

Based on secretary's report by

C. C. HASTY, JR.

Ryan Aeronautical Co.

ANALYSIS of maintenance experience provides a basis for writing specifications for new equipment with an eye to lowering future maintenance costs and downtime. The three main areas to be considered and some of the factors in their solution are:

Wear

1. Protection of wearing parts.
2. Proper lubrication.
3. Dynamic balance of high-speed rotating parts.
4. Elimination of unnecessary parts.

Breakage

1. Operator should have positive control at all times.
2. Automatic and positive stops.
3. Safety clutches and shear pins.
4. "Fool-proof" features.
5. Sufficient accessories (filters, coolers, and such).
6. Standardization of directional controls.

Maintenance Labor Costs

1. Accessibility to all parts for easy repair.
2. Increased use of unit-type replacement.

The initial design of new equipment

TUBING AIDS by

Fusionweld

Spark Solutions to Production Problems



HEATING ELEMENTS—Fusionweld thin-wall tubing is widely used by manufacturers of electrical appliances containing low temperature calrod heating elements, such as electric irons, cookers, fryers, hot water heaters, etc.



OIL LEVEL INDICATOR TUBES—Avon's low cost, high production fabrication and forming of steel tubing with new spot welding technique in attaching brackets, clips or fittings to Fusionweld thin-wall tubing has been widely adopted by most motor car manufacturers.



TUBULAR PUSH RODS—A current automotive development replacing solid steel push rods with Fusionweld steel tubing. These have swaged ends or hardened steel inserts (spot welded) in tubing ends. A high degree of concentricity is maintained with maximum run-out held to .020.

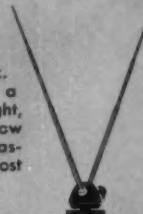


GAS SPACE and WATER HEATER TUBES—Several new developments by Fusionweld have cut costs by eliminating expensive brass fittings and non-ferrous tubing or pipe from thermostats to burners, replacing with low cost inverted flare nuts and one piece steel fittings brazed or spot welded to Avon steel tubing.



ENGINE OIL FILTER TUBES—For both internal and external use with brazed fittings attached. Fusionweld tubing can be beaded, swaged and sheared to meet specifications of motor car, truck and tractor manufacturers.

MISCELLANEOUS APPLICATIONS—Fusionweld thin-wall tubing is extensively used by toy manufacturers, umbrella and TV antenna makers, also for electric light fixtures, tubular furniture, etc. Fusionweld offers a tough, light weight, extremely ductile, low cost steel tubing easily formed for most requirements.



OIL SPACE and WATER HEATER TUBES—Fusionweld thin-wall tubing provide manufacturers of this and similar equipment with smart economies by replacing non-ferrous tubing and fittings with special steel fittings combined with Fusionweld steel tubing.



CHASSIS FUEL LINES—Avon furnishes millions of feet yearly of Fusionweld steel tubing to car manufacturers for fuel lines (from gas tanks to fuel pumps, to carburetors). These are completely fabricated on automatic bending machines to provide important economies and lower assembly costs.



Our latest tubing catalog mailed on request. Let us quote on random or cut to length sizes— $\frac{3}{16}$ O.D. to $\frac{3}{4}$ O.D.—plain or ferne coated—or fabricated and formed to blueprint specifications.

AVON

TUBE DIVISION

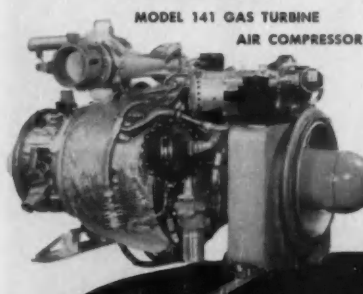
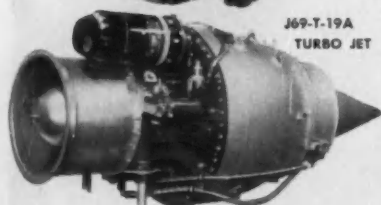
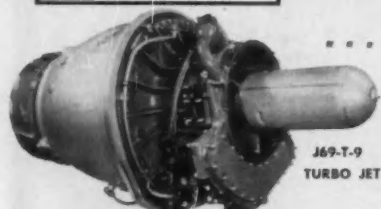
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... the T-37 Twin Jet Trainer with C. A. E. Turbine Power

Air Corps flight training routine took a significant step forward recently, when the T-37 twin jet trainer entered its Phase VIII testing at Bainbridge Air Base, Georgia. Twenty hand-picked officers embarked on a course known as PROJECT PALM, with the two-way goal of training for them, and suitability testing for the plane. This new high-performance ship advances the jet phase of fliers' training to an earlier stage in the training schedule, speeding the transition from propeller-driven planes to jets, with gains in both safety and economy. Twin J69-T-9 turbines by C.A.E. provide the power.



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is probably the most important, but often overlooked, factor in lowering future maintenance costs. Other members of the panel which developed the information in this article were: A. Auerbach, Ryan Aeronautical Co.; W. Fore, North American Aviation, Inc.; H. A. Smith, General Dynamics Corp.; L. Garrison, Boeing Airplane Co.; S. Chew, Douglas Aircraft Co., Inc.; and W. Lindstrand, Northrop Aircraft, Inc.

To Order Paper No. 321 . . .
on which this article is based, see p. 5

Realistic Modeling Reduces Designing Risk

Based on talk by

HARRY E. CHESEBROUGH

Chrysler Corp.

(As reported by R. D. Chandler, SAE Central
Illinois Section field editor)

IN spite of expert allowances made when new models are styled, it is impossible to develop surfaces properly in fractional scale so that they will look right in full scale. Models must also be viewed in big surroundings. We put ours on a rigid enough frame to permit moving out of doors.

Recently, we have developed a technique for painting models so that from a reasonable distance they look like finished cars. The parts which will be bright metal are covered with aluminum foil. Glass is installed in the upper structure. At 50 ft the models look like completed automobiles. The more realism incorporated in the finished model the better will be the final decision, or the less the risk of making a poor one.

Loop-, Thru-Scavenged 2-Stroke Engines Compared

Based on paper by

C. F. TAYLOR and A. R. ROGOWSKI

Massachusetts Institute of Technology

A. L. HAGEN

J. J. Henry Co., Inc.

and

J. D. KOPPERNAES

Aluminum Co. of Canada

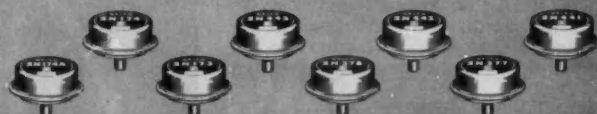
INVESTIGATIONS of loop-scavenged and through-scavenged 2-stroke engines under conditions that actually allowed close comparison of the two methods showed that:

1. With equal effective port areas and the same (symmetrical) timing, the through-scavenged cylinder shows no significant advantage over the loop-scavenged cylinder in respect to trapping efficiency.
2. For both cylinders, with symmet-

DELCO'S FAMILY OF HIGH POWER TRANSISTORS



Typical Characteristics at 25°C



	DT100	** 2N174A	2N174	2N173	2N443	2N278	2N442	2N277	2N441
Maximum Collector Current	13	13	13	13	13	13	13	13	13 amps
Maximum Collector Voltage (Emitter Open)	100	80	80	60	60	50	50	40	40 volts
Saturation Voltage (13 amp.)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7 volts
Max. Square Wave Power Output at 400 ~ P-P*	400	310	310	225	225	180	180	135	135 watts
Max. Sine Wave Power Output at 400 ~ P-P*	180	140	140	100	100	80	80	60	60 watts
Power Dissipation (Stud Temperature 25°C)	70	70	70	70	55	55	55	55	55 watts
Thermal Gradient from Junction to Mounting Base	1.0°	1.0°	1.0°	1.0°	1.2°	1.2°	1.2°	1.2°	1.2° °C/watt
Nominal Base Current 1s ($V_{EC} = -2$ volts, $I_C = -1.2$ amp.)	-19	-19	-19	-13	-24	-13	-24	-13	-27 ma

*Adequate Heat Sink

**Designed to meet MIL-T-19500/13 (USAF) 18 JUNE 1957

Offer a wide range of performance characteristics to meet your switching, regulation or power supply requirements

These nine Delco Radio alloy junction germanium PNP power transistors are now in volume production. They are characterized by high output power, high gain, and low distortion. And all are normalized to retain superior performance characteristics regardless of age.

Check the data chart above—see how they fit your particular requirements in current switching, regulation or power supply. Write for detailed information and engineering data. Delco Radio maintains offices in Newark, N. J. and Santa Monica, Calif. for your convenience.

DELCO RADIO

Division of General Motors
Kokomo, Indiana

rical timing, the best ratio of exhaust-port to inlet-port effective area appears to lie in the neighborhood of 0.6.

3. Unsymmetrical timing is an effective method of improving trapping efficiency. Whether the added mechanical complication necessary to achieve unsymmetrical timing is justified will depend on particular circumstances.

4. Allowing for experimental error, the values of net indicated fuel economy with fuel injection show no significant difference between the two cylinders, with symmetrical timing. With the poppet-valve engine, the small change in net isfc x trapping efficiency as the exhaust-port timing is advanced is perhaps also within experimental error. The flow coefficient was not reduced by the advance in exhaust-valve timing, and therefore the apparent decrease in fuel economy cannot be attributed to greater scavenging mep.

To Order Paper No. 247 . . .
on which this article is based, see p. 5

New Plating Technique Checks Embrittlement

Based on paper by

W. F. HAMILTON
M. LEVINE
and
R. C. MAUER

Lockheed Aircraft Corp

HYDROGEN embrittlement of high-strength steels can be relieved best by cadmium electroplating at high current densities—that is, where cadmium density is low. This is the finding of experiments concerned primarily with residual embrittlement (degree of embrittlement retained by a processed specimen after relief bake) as distinct from initial embrittlement immediately following electroplating.

The effect of varying current density on residual embrittlement at a plate thickness of 1 mil was as follows:

1. At the low and medium current densities 10–50 asf, embrittlement was more severe than when electroplating was done in the range of 60–80 asf.

2. When 0.02 oz per gal of a commercial brightener was added to the bath, somewhat similar results were obtained.

3. At medium and high current densities of 30–60 asf, there was a good correlation between baths.

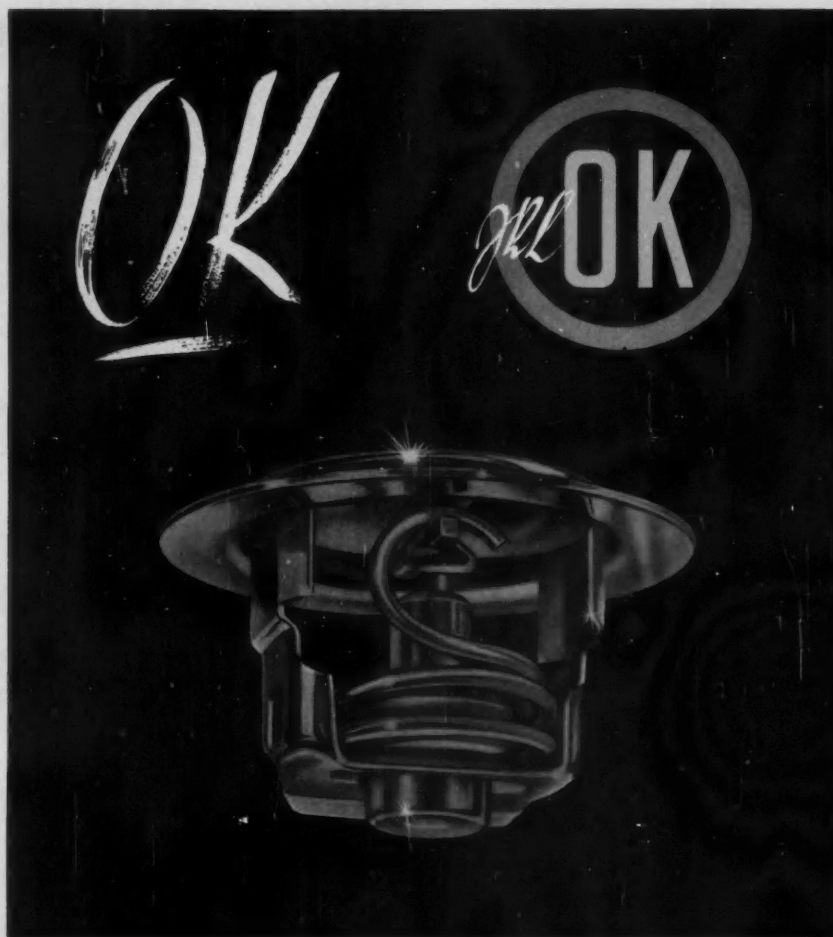
4. At 20 and 25 asf discrepancies occurred. Rods plated at 20 or 25 asf in the modified bath were more effectively relieved of embrittlement by baking than those plated at either 10 or 30 asf. Greatest relief was still obtained, however, at the higher current

densities.

At a constant cadmium plate thickness, the density of the cadmium decreases with an increase in current density at which the plate is deposited. The drop in plate density is gradual from 10 to 60 asf and abrupt above 60 asf. If we assume, (a) nonporous cadmium is a barrier against diffusion of hydrogen and, (b) the porosity of cadmium increases with decreasing density, the experimental results may be explained. Thus, an embrittlement relief treat-

ment, such as baking, where evolution of absorbed hydrogen occurs, is more effective when the cadmium density is lower. Generally, if low or medium current densities are used, a higher density, lower porosity, cadmium plate results and relief by baking is less effective.

The drop in plate density correlates well with the decrease in plating efficiency. The increased evolution of hydrogen as evidenced by reduced plating efficiency at high current den-



*Men who know best
put their O.K. on*

DOLE THERMOSTATS

sity may account for the decreased density or increased porosity of the cadmium plate. It was observed that at current densities of 30-40 asf, using the original bath, where relief was less complete after baking, the deposited cadmium was very smooth and bright in appearance. At the same current densities, using the modified bath, the cadmium deposited was granular in appearance and gray in color.

To Order Paper No. 218 . . .
on which this article is based, see p. 5

Cooling vs High Temp Electronic Components

Based on paper by

R. R. JANSSEN

North American Aviation, Inc.

THE next generation of aircraft cannot afford high-temperature electronic components if the weight penalty is greater than 15-30%. Existing

cooling systems will provide a lighter solution if these limits are exceeded.

This prediction is based on a supersonic mission time of 1 hr at Mach 3-4, with equipment grouped to permit easy cooling. Special cases of remotely mounted equipment can justify higher weight penalties.

Overlaying the weight problem is the reliability of electronic gear. Higher reliability is usually achieved by derating the part. This derating can be obtained by greater cooling or a higher-temperature component, however, a separate cooling system is another group of parts that may fail and abort the mission.

To Order Paper No. 230 . . .
on which this article is based, see p. 5



Year after year more and more automotive manufacturers choose Dole. Today, Dole Thermostats are standard equipment on 38 makes of passenger cars, trucks, tractors, commercial vehicles, industrial and marine engines. This includes 19 out of 20 top passenger cars*.

Dole has earned this position of leadership through their never-ending program of research and development and their constant adherence to the highest standards of quality in engineering and manufacturing. Dole Thermostats have passed every test for accuracy and dependability under all operating conditions.

So . . . it's no wonder that men who know best put their O.K. on Dole Thermostats. It's just good common sense.

*As listed in Automotive News.

Control with

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Road-Lab Octane Correlation Found Valid

Based on paper by

R. B. FELL

and

H. F. HOSTETLER

Standard Oil Co. (Ohio)

FROM a test program which involved 6000 road octane determinations in four high-compression cars, Standard Oil Co. (Ohio) researchers have concluded that:

1. There is a valid correlation between road antiknock performance and the Research and Motor laboratory octane ratings.

2. The relative importance of Research and Motor octane ratings on road octane performance is influenced by make of car, engine speed, throttle position, and distributor advance characteristics.

3. The hydrocarbon-type factors are not an important influence (independent of the Research and Motor octane ratings) on the Modified Uniontown road octane ratings. Aromatics improve high-speed Modified Borderline octane ratings, whereas olefins have a small independent depreciating effect.

4. Laboratory to road regression equations are valuable in predicting road octane performance from laboratory octane data and in tailoring engine distributors to match available fuels.

Over 200 gasolines were road-rated by both the Modified Uniontown and the Modified Borderline test techniques in the test program which brought the conclusions noted. These fuels ranged from 97 to 105 Research octane, and from 86 to 104 Motor octane number, and covered a wide concentration range of commercially available blending fuels.

To Order Paper No. 263 . . .
on which this article is based, see p. 5



What to do when your "baby" develops sales appeal overnight

Don't push the panic button. Call THE MAN FROM INTERNATIONAL for very special delivery service of very special product power

Naturally, you should be very proud when your new pilot model performs exactly the way you hoped it would when you finalized the blueprints. But your product plans should also provide for ways of supplying the sales department with prompt production when the sales manager tells you your "baby" has developed terrific sales appeal, almost overnight.

This isn't the time to press the panic button. It's time to call in **THE MAN FROM INTERNATIONAL**. You can count on him to help you out of any tight spot, especially one like this. He can provide very special delivery service on dependable International en-

gines sized and powered not only for your pilot models but also for quantity production. He sells 20 diesel and carbureted engines you can put in your product and forget about from a service standpoint. And he can deliver any of them fast.

Give him a ring at his headquarters in Melrose Park, Illinois—Fillmore 3-1800—today. You'll find him extremely helpful in solving any production problem that calls for fine engines delivered without red tape. And you'll find the customer-pleasing power he sells will even make your sales manager happy.

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A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors... Self-Propelled Scrapers... Crawler and Rubber-Tired Loaders... Off-Highway Haulers... Diesel and Carbureted Engines... Motor Trucks... Farm Tractors and Equipment.

New Members Qualified

These applicants qualified for admission to the Society between November 10, 1957 and December 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group:

Albert A. Nicholls (A).

Atlanta Section:

John E. Marder (M).

Baltimore Section:

Rene A. Lambert (J), Paul R. Shepler (M).

British Columbia Section:

John C. Midgley (A), Frank M. Smith (A).

Buffalo Section:

Lewis L. Dollinger, Jr. (M), Paul F. Wilber (M), Wallace E. Wilson (M).

Canadian Section:

Hector M. Lazzarotto (M), Carmine Luciani (M), Ian H. Mitchell (J), James Alfred Montgomery (J), Arthur Sledin Moss (M), Ronald Wilson (J).

Central Illinois Section:

Joseph M. Bertschinger (M), John M. Dickerson (J), Hubert Alvin England (A), Robert W. Gendron (M), Mark Edward Kowalske (J), Julio Eladio Laredo (M).

Chicago Section:

George Elliott Anderson (M), John H. Freeman, Jr. (J), Delmar Clyde Hepker (J), Owen J. Higgins (M), Arthur Harold Krumhaus (M), Cesareo Lopez (J), Robert James Mustari (J), James L. Robertson (M), James W. Tharp (J).

Cleveland Section:

Charles Frederick Aured (J), Ralph H. Daugstrup (J), Thomas Pierre Gardner (J), J. Kurt Hill (J), Edward H. Landgren (M), Nolan H. Leatherman (J), Robert Hutchins Noble (J), Frank Schindler (M), Herbert P. Schoeck, Jr. (J), J. Paxton Van Sweringen (M).

Colorado Group:

William J. Perry (A).

Dayton Section:

Robert Stanton Burns (M), Robert G. Hillfield, Sr. (M), John Arthur Moran (M), Arland W. Rike (M), James A. Weybright (J).

Detroit Section:

Edward G. Benya (M), Donald Peter Boarder (J), Frederick W. Burgie, Jr. (A), Karl S. Burnside (A), Murray William Bursott (J), Roy E. Calcagno (J), William Smith Christenberry (J),

Richard E. Clay (A), Donald Cox (A), Joseph F. Craig (A), Richard J. Cumming (J), Robert O. Dameron (M), Ernest G. Davis (J), Robert L. Dega (M), Stephen Anthony Dier (M), Daniel William Doran (J), Frank G. Falvey (M), Robert E. Farrell (J), James D. Fleming (M), F. D. Fountain (A), Richard A. Graves (M), Robert Dale Hisson (J), Delaine C. Johnson (M), J. W. Knoblock (M), Robert D. Knoll (J), Frank S. Kuharich (M), John M. Lackner (A), Ralph W. Lithgow (M).
Continued on page 133

ROCKFORD

MORLIFE® Spring Loaded CLUTCHES Provide



MORE GRIP WITH LESS SIZE

Because ROCKFORD Morlife Clutches handle double the amount of torque handled by ordinary friction clutches, they enable design engineers to reduce the effect of centrifugal force developed by modern, high-speed engines. By cutting down the required diameter of the clutch, they reduce weight. By insuring better heat disposal, they multiply the clutch's work-life.



SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

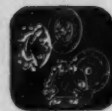


ROCKFORD Clutch Division BORG-WARNER

316 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 30 So. Wabash, Chicago 3, Ill.

CLUTCHES



Small Spring Loaded



* Heavy Duty Spring Loaded



Oil or Dry Multiple Disc



Heavy Duty Over Center

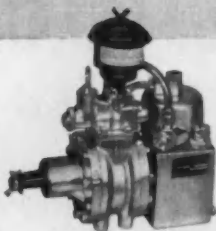


Power Take-Offs



Speed Reducers

Rigid quality control
in manufacturing the
Wagner
ROTARY
AIR COMPRESSOR
and other air brake
components improves operating
efficiency and service life



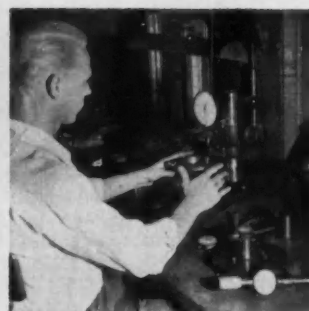
The superior operating features of Wagner Rotary Air Compressors are directly related to Wagner's Rigid Quality Control manufacturing program—an important reason owners have so little trouble when the compressors are put into operation. At the factory every unit must pass careful inspection and run-in tests to assure that each compressor provides an adequate supply of air pressure at all times, with fast air recovery; and can provide safe, dependable performance and long service life.

If service should be needed—the entire compressor can be completely disassembled, serviced and put back into operation in a few hours. There are Wagner factory service branches in 23 major cities and a vast network of Wagner Air Brake Distributors throughout the United States and Canada to give prompt and efficient service on any air brake need.

It will pay you to include Wagner Air Brake Systems as standard equipment on the vehicles you manufacture. For further information, send for a copy of Bulletin KU-201.



1. Accurate machining assures the smooth, cool operation of the Wagner Rotary Air Compressor. Close dimensions on all planes of the rotor eliminate vibration . . . permit compressor blades to function smoothly at high speeds.



2. Accurate machining and gauge testing of the stator, as well as the rotor, also contributes to the rotary compressor's ability to operate for long periods of time without developing leaks or losing efficiency.



3. Compressor shafts are given the "cold box" treatment. When exposed to very low temperatures, the shaft diameter contracts. This altered shaft diameter allows proper insertion into a heated rotor to form a strong, composite unit.



4. Compressor rotors are subjected to high oven temperatures to expand rotor diameters. Shafts and rotors joined together under these extreme conditions resume their original relative size to create an extra strong assembly.



5. Assembled rotary compressors are heated up to air lines and operating air pressure is applied for leakage tests. While holding pressure, entire compressor is submerged to determine whether any air is escaping.

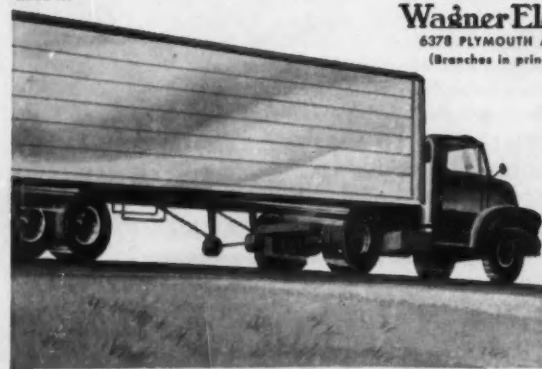
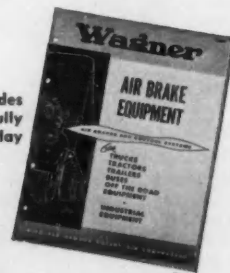


6. Every Wagner Rotary Air Compressor is given a rigorous "run-in" test to determine its resistance to overheating and its over-all performance. Running temperatures, vibration, noise and air output are carefully noted and analyzed.

WKS8-1A

Wagner Electric Corporation
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The complete Wagner Air Brake Line includes many types and kinds of equipment—all fully described in Catalog KU-201. Write today for your free copy.



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New Members Qualified

Continued

Lun King Liu (J), Thomas E. Lootens (M), Ronald Anthony Makowski (J), Thomas A. Martin (A), Eric Mittelstadt (J), Francis Allen Mohler (M), Archibald R. Newton, III (M), Donald J. Oesterle (M), Phillip J. Oeth (J), Clarence N. Ohashi (J), Dale A. Palmer (M), Fredric Noel Parrill, Jr. (J), Vaughn Allen Patterson (J), William W. Pflug, Jr. (A), Richard E. Rasmussen (J), Robert L. Reid (J), Albert S. Sheppard (A), Eugene E. Sowers (M), Charles W. Storms (A), Ronald J. Swanson (J), Robert E. Thoreson (J), Alan Walter William Turner (J), Henry H. ZurBurg (M).

Indiana Section:

Earl N. Daggy, Jr. (M), Jesse B. Fox (J), Norman B. Keith (J), Richard S. Koontz (J), James M. Leahy (J), Aladar Simko (J).

Kansas City Section:

Anthony Edward Cocoros (M), John R. Colgan (A), Donald Lee Rich (J).

Metropolitan Section:

Joseph H. Chislow (M), Thomas Edward Collier (J), Richard L. Demmerle (M), Thomas C. Foster (M), Webber H. Glidden (J), Fred Arthur Grauman (J), Harold G. Haas (M), Erich A. Herold (M), J. Gordon Hoffmann (M), Edward S. Janicke (A), Eli H. Lesser (J), Karl H. Neulinger (J), Henry J. Ogorzaly (M), Paul Thomas Olsen (J), Frank P. Reggio (A), Henry Rottersman (M), Ernest Albert Samuels (A), Irving Sochrin (M), Karl-Gustav Stark (M), Herbert Henry Vickers (M), William W. Wight (M).

Mid-Continent Section:

Gerald Lynn Smith (J).

Mid-Michigan Section:

James F. Cutler (J), Richard E. Durkee (J), Joseph Frank Kolder (J), Ivan K. Lukey (J), Duane H. McCormack (J).

Milwaukee Section:

Martin Drapkin (J), Robert L. Greivell (M), Harold J. Lonn (M).

Mohawk-Hudson Section:

Frank W. Fernald (M), Theodore C. Schallehn (A).

Montreal Section:

George Alexander Adams (J), Leo

Paul Caron (A), George Fisher (A), Maurice C. Lavigne (J), S/L E. Glen D. Maynard (M), John Wylie Noonan (M), Melvin Arthur Clarke Smith (A), Gerard Vaillancourt (A).

New England Section:

Myles Anderberg (J), Gerard Daniel Eggleston (J), Leon R. Wood (A).

Northern California Section:

Barry B. Abrahamson (J), Homer W.

Harralson (A), Larry L. Lynes (J), Peter L. Marz (J).

Northwest Section:

Harlan C. Ganung (M).

Oregon Section:

Robert H. Feely (A).

Philadelphia Section:

Charles V. Martin (A), Bruce O. Mc-

Continued on page 134

Up where the boiling point is low...



...Vernatherm® controls assure correct operating temperature for these BIG Diesel Machines



Here is your answer to tough coolant problems on Diesel and heavy-duty gasoline engines . . . Detroit Controls Vernatherm . . . a solid-charged thermostat that will take all the punishment big engines and rough duty can give it, and still give positive, precise coolant control *indefinitely*.

Pioneered by the Detroit Controls Division, these Vernatherm thermostats have a reputation for solving knotty problems in the roughest kinds of service.

Call on a Detroit sales engineer for application assistance . . . or write for Bulletin 213, which gives basic data on Vernatherm Controls and their function in modern engine design.

Quality Protects Your Investment--

AMERICAN-Standard Quality Is Available At No Extra Cost.



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DETROIT CONTROLS

Division of AMERICAN-Standard



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Continued

Cracken (M), William T. Robinson (M), David L. West (J).

Pittsburgh Section:

James B. Austin (M), Kenneth R.

Feder (J), Richard J. Ingalls (J), Chester F. Klages, Jr. (J), Stanley Kmonk (M), Allen W. Kyllonen (J), Wesley M. Rohrer, Jr. (M).

St. Louis Section:

Harry Richard Callaway, Jr. (J), Charles W. Fowlkes (J), John C. Lebens (M), Jaan Tabur (J), Hartland B. Ukes (J).

San Diego Section:

John F. Brown (J), Alan LeRoy

Clarke (J), Forest Charles Harris (J), Charles Edward Klebert (J), Walter D. Metcalfe (J).

Southern California Section:

Dean O. Baker (J), Clifford E. Bernard (M), Manette Brandt (J), Alvin L. Dubrow (J), Theodore F. Fore (M), Leo Lofchle (A), Donald L. McClure (J), Charles M. Miller (M), Phillip Nuccio (J), Kenrick C. Palmer (J), Irving C. Poling (J), Robert W. Rowley (J), Nelson H. Shappell (M), Marvin Silver (J), Sampson James Smith, Jr. (J), Jack Patrick Solomons (A), Richard D. Tobin (J), Wallace I. Vance, Jr. (J), Tom Yearian (J).

Southern New England Section:

Henry H. Adams, Jr. (J), Nelson L. Andrews (M), George John Fabian (J), John N. Humber (M), Paul Walter Pillsbury (J), Donald L. Witt (J).

Syracuse Section:

James E. Buxton (M), John Winston Kramar (J), Donald L. Miller (M).

Texas Section:

Carl H. Fox (M), John Edward Sholes (J), Louis Vincze, Jr. (J).

Texas Gulf Coast Section:

Capt. James Edwin Light, Jr. (J).

Twin City Section:

James D. Andersen (M), Kenneth Arne Kujanson (J).

Western Michigan Section:

John B. Radtke (M).

Outside Section Territory:

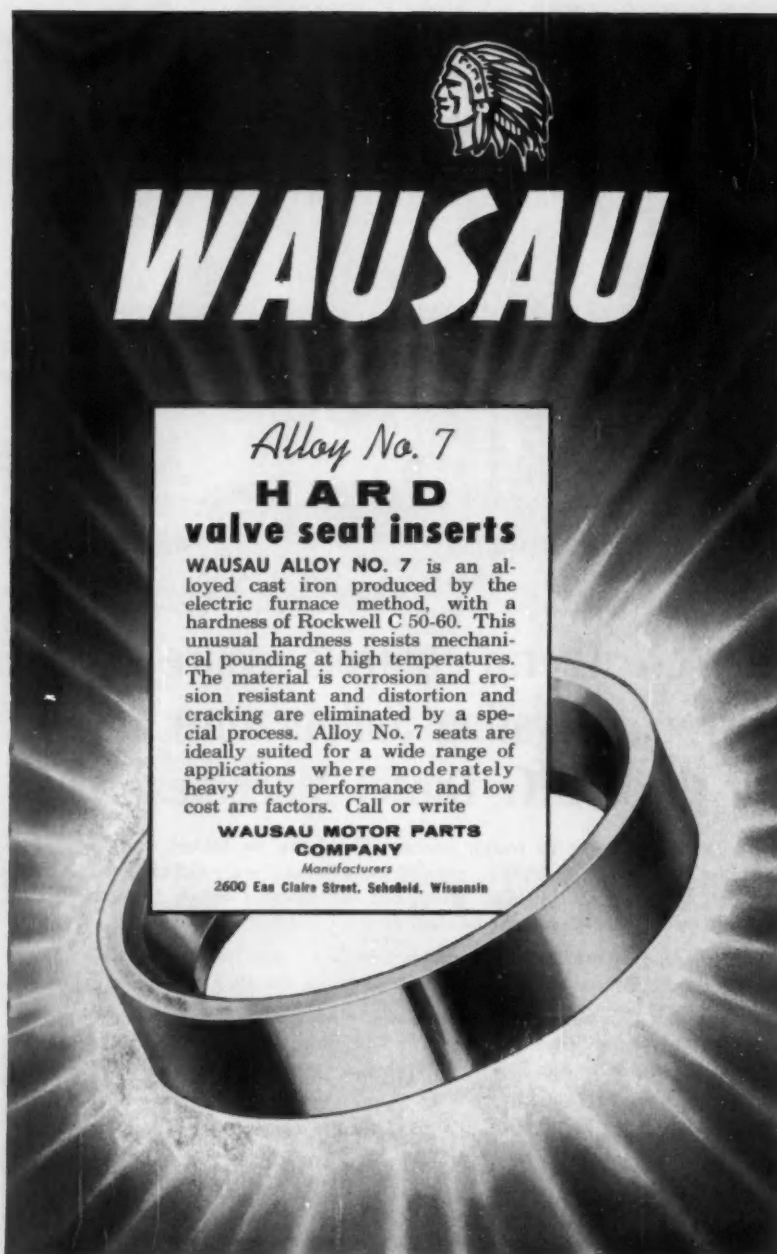
Capt. Harvey M. Bender (A), Wesley D. Campbell (M), W. F. Eaton (M), 2nd Lt. Ronald J. Plattum (J), Col. Homer Thomas Lambert (M), Ronald P. Lenert (J), John W. Meulendyk (M), William L. Snider (M), Christian Paul Tschudi (J).

Foreign:

Charles Abell (M), England; Alan Charles Hill (M), England; Clifford H. Jackson (M), England; Farid Khan (J), Pakistan; Anant Ramchandra Kotnis (M), Finland; N. Ramachandran Nair (J), India; Dennis Ronald Sandbrook (M), England; Robert G. Sestier (J), Mexico.

Applications Received

... starts on page 135



Alloy No. 7
HARD
valve seat inserts

WAUSAU ALLOY NO. 7 is an alloyed cast iron produced by the electric furnace method, with a hardness of Rockwell C 50-60. This unusual hardness resists mechanical pounding at high temperatures. The material is corrosion and erosion resistant and distortion and cracking are eliminated by a special process. Alloy No. 7 seats are ideally suited for a wide range of applications where moderately heavy duty performance and low cost are factors. Call or write

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Applications Received

The applications for membership received between November 10, 1957 and December 10, 1957 are listed below.

British Columbia Section:

Aidan Blundell, Joseph Francis Gunne, Henry (Harry) Lewis Perry, Joseph Edward Robinson.

Buffalo Section:

Jerold James Gilmore.

Canadian Section:

William Blake Dodds.

Central Illinois Section:

James E. Gee, Richard J. Heintzman, Darwin Ray Larsen, William R. Metzke, Paul W. Padrutt, Michael K. Stratton.

Chicago Section:

Sumner L. Barton, Jonathan Freeman Bushnell, Charles Chimento, Richard P. Clemmer, G. E. Doherty, Marvin E. Holmgren, C. A. Kroft, Raymond H. Mattsen, Fred E. Newmarker, Dean S. Robertson, Richard S. Roeing, John J. Santucci, James P. Schuster.

Cincinnati Section:

Carl S. Hellman.

Cleveland Section:

Robert W. Biggs, Wallace L. Dennis, Walter A. Fritsch, Robert A. Hein, Arnold H. Hoffer, Paul John Kolarik, Eugene E. McMannis, Clifton W. Perryman, Jr., William Earle Sedden.

Dayton Section:

Gerald L. Furrey, H. Frederick Hess, Jr., Leroy Huelskamp, Eldon Ray McClure.

Detroit Section:

Richard V. Anderson, Alfred E. Bannister, Harold E. Barnum, Charles L. Bruce, Jr., Robert Buchanan, Thomas E. Burke, Robert A. Burton, Jack M. Clanton, William W. Dodson, Robert D. Dushaw, Charles E. Edwards, Marvin E. Fawley, Stanley Fleszar, Robert J. Hammel, Thomas P. Hendry, Max L. Hoolihan, Donald R. King, Albert H. Leese, Robert B. Longmuir, Eugene Malanyn, Paul Louis Martin, Ira Kenneth McAdam, Harold W. Meinert, Richard F. Merritt, Duane Francis Miller, John H. Qualls, William Reynolds, Clarence B. Richey, Darwin E. Rightmire, James Gilbert Roddewig, Charles Roberts Russell, Carl H. Schellenberg, Willis L. Schultz, Russell P. Stebar, Charles L. Stevens, Kenneth H. Taylor, Paul van Buuren, Kenneth E. Welke, James Richard White.

Hawaii Section:

Collin J. Fryer, Thomas M. Ishimoto,

Continued on page 139



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IN RINGS FOR
AUTOMATIC
TRANSMISSIONS**



Oldest manufacturer of sealing rings in the industry WAUSAU was first to produce rings for automatic transmissions, power steering and many other automotive and industrial applications.

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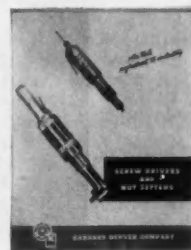
Gardner-Denver (Keller) 000RSD and 12A-2 screw drivers with cushion clutch, magnetic bit holder and Phillips insert bit assembling dual headlights for 1956 cars.

These Air-Operated Screw Drivers Are Paying for Themselves

If you drive only 400 screws a day, a Keller air-operated screw driver, such as those shown above, will pay for itself in six months. These lightweight air tools are easier on their users . . . help them keep pace with fast-moving assembly-line work.

Despite their high load factor, Keller pneumatic screw drivers run cool always. They have the right combination of torque, adjustable clutch and magnetic holding of screws for fast, efficient driving. They are the modern way to reduce assembly-line time and costs.

Send for the 40-page booklet. This Gardner-Denver booklet gives complete information about Keller screw drivers and nut setters, as well as other Keller air tools and accessories. A copy is yours for the asking.



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IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

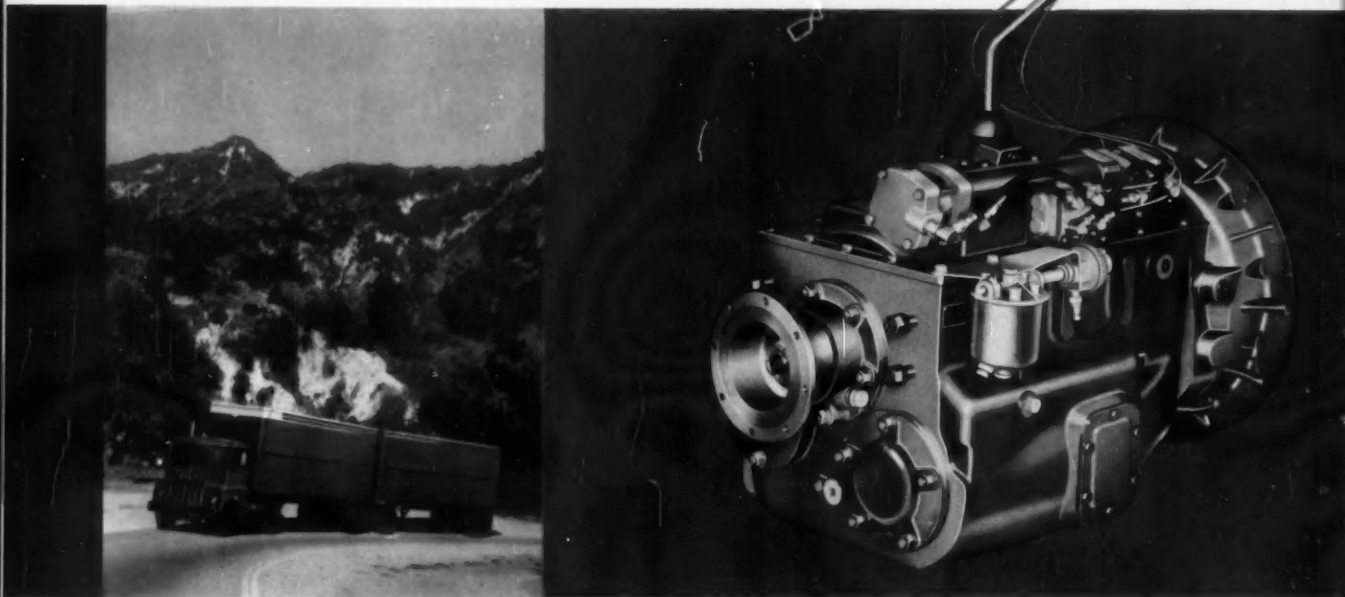
Gardner-Denver Company, Quincy, Illinois

**How the new
Spicer 12-speed
transmission
cuts your
operating costs**



New Spicer 12-speed Synchro-Master Transmission

lowers fuel consumption and increases payload



12" shorter and 200 pounds lighter than any other multiple-speed transmission of comparable capacity

Produces the close steps required to maintain engine speed at maximum RPM—Avoids engine lugging

No 2-speed axle required

No auxiliary transmission needed

Blocker-type synchronizer in all speeds, forward and reverse

All six low range ratios in reverse • Forced-feed lubrication • Screen for filtering oil • Standard 6-bolt S.A.E. power takeoff apertures on each side • Tower or remote control type • Replaceable bearing retainer inserts in all case bores.

This new transmission is unmatched in efficient power transmission for heavy duty vehicles. There has never been a transmission that has increased both driver and vehicle efficiency so much and at the same time requires so little initial investment and maintenance expense.

WRITE FOR BOOKLET

Dana engineers want to help you adapt this revolutionary new Spicer transmission to your heavy-duty truck requirements. Your letter, wire, or telephone call will receive immediate attention.



DANA CORPORATION • Toledo 1, Ohio

DANA PRODUCTS Serve Many Fields:

AUTOMOTIVE: Transmissions, Universal Joints, Propeller Shafts, Axles, Power-Lok Differentials, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Clutches, Frames, Forgings, Stampings.

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AGRICULTURE: Universal Joints, Propeller Shafts, Axles, Power Take-Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

MARINE: Universal Joints, Propeller Shafts, Gear Boxes, Forgings, Stampings.

Many of these products manufactured in Canada by Hayco Steel Products Limited, Merriton, Ontario

DANA

Spicer

Applications Received

Continued

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Russ Byram Dhondy, Paul Roscoe Norton, Jr., Ewing Alan Sharp, Glenn H. Voirol.

Metropolitan Section:

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Mid-Michigan Section:

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N-A-X[®] HIGH-STRENGTH STEELS

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WITH LIGHT WEIGHT



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Hamlintainers—the versatile knock-down, pallet-type steel shop and shipping boxes built by Hamlin Metal Products Corp., Akron, Ohio—make still another profitable example of the adaptability of N-A-X HIGH-STRENGTH steels.

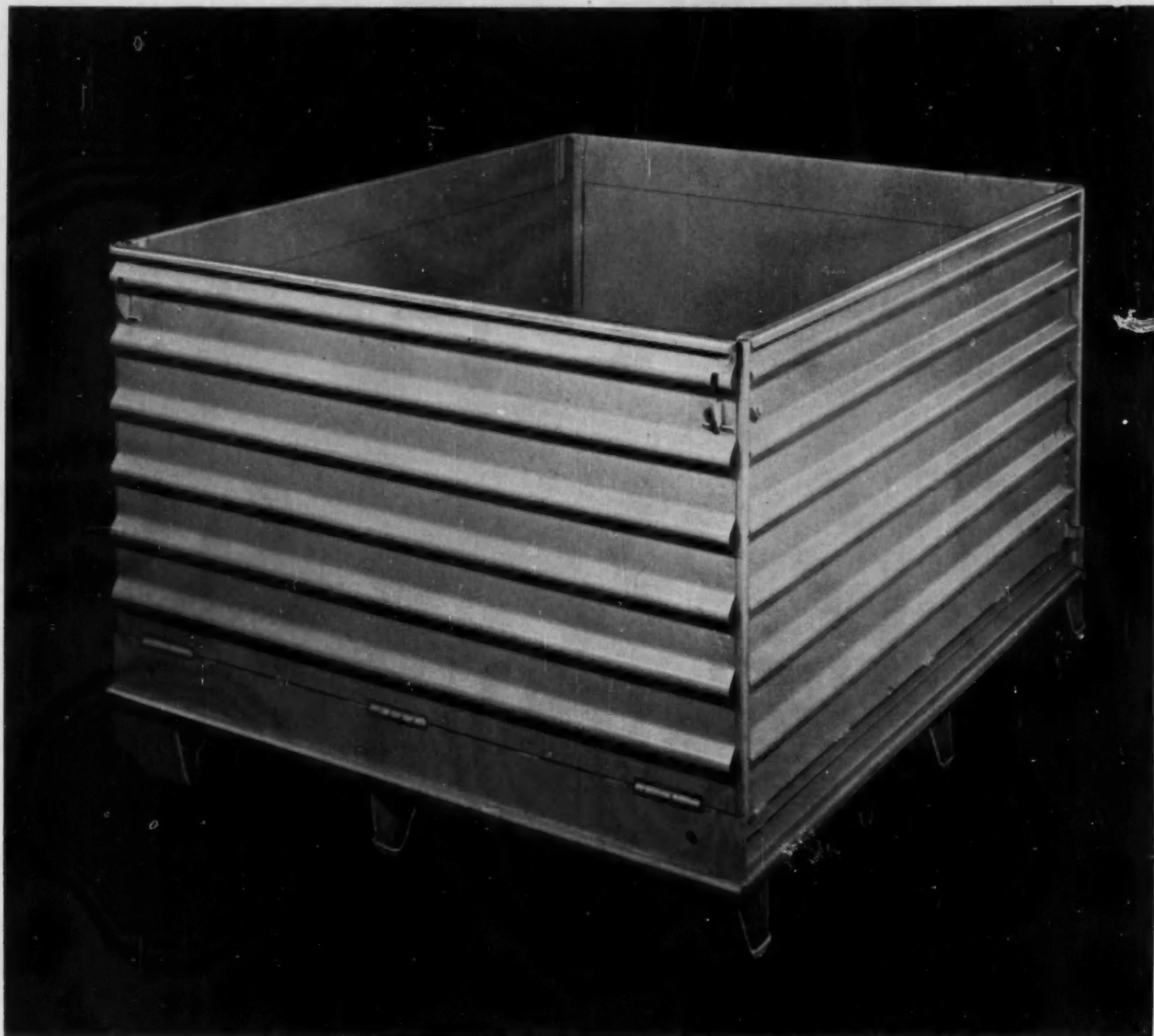
Developed in answer to Hamlin's own shop problems, *Hamlintainers* quickly proved themselves in the nation's leading automobile, aircraft and appliance manufacturing plants. On the job *Hamlintainers* must have strength to carry heavy fabricated parts and still be light enough for fast, easy plant handling and minimum return freight costs.

Like so many producers, Hamlin looked for and found these characteristics of strength with lightness in N-A-X HIGH-STRENGTH steels, along with other significant benefits.

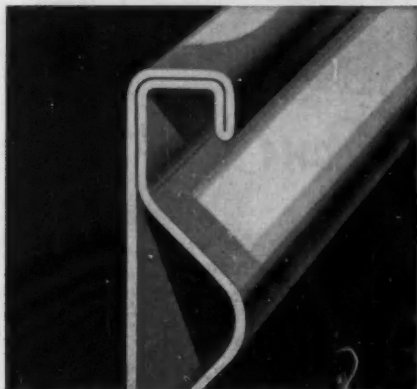
Check These Important Advantages for Your Job: N-A-X HIGH-STRENGTH steels—both N-A-X HIGH-TENSILE and N-A-X FINEGRAIN—compared with carbon steel, are 50% stronger . . . have high fatigue life with great toughness . . . are cold formed readily into difficult stampings . . . are stable against aging . . . have greater resistance to abrasion . . . are readily welded by any process . . . offer greater paint adhesion . . . polish to a high luster at minimum cost.

Although N-A-X FINEGRAIN's resistance to normal atmospheric corrosion is twice that of carbon steel, N-A-X HIGH-TENSILE is recommended where resistance to extreme atmospheric corrosion is important.

For whatever you make, from steel boxes to boxcars, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight and economy into your products. Let us show you how.



Hamlintainers are the result of more than five years of intensive research, development and practical on-the-job testing. Thanks to N-A-X HIGH-STRENGTH steels, Hamlintainers are tight enough to hold rivets, strong enough to carry forgings and light enough for moving by any standard plant fork-lift truck.



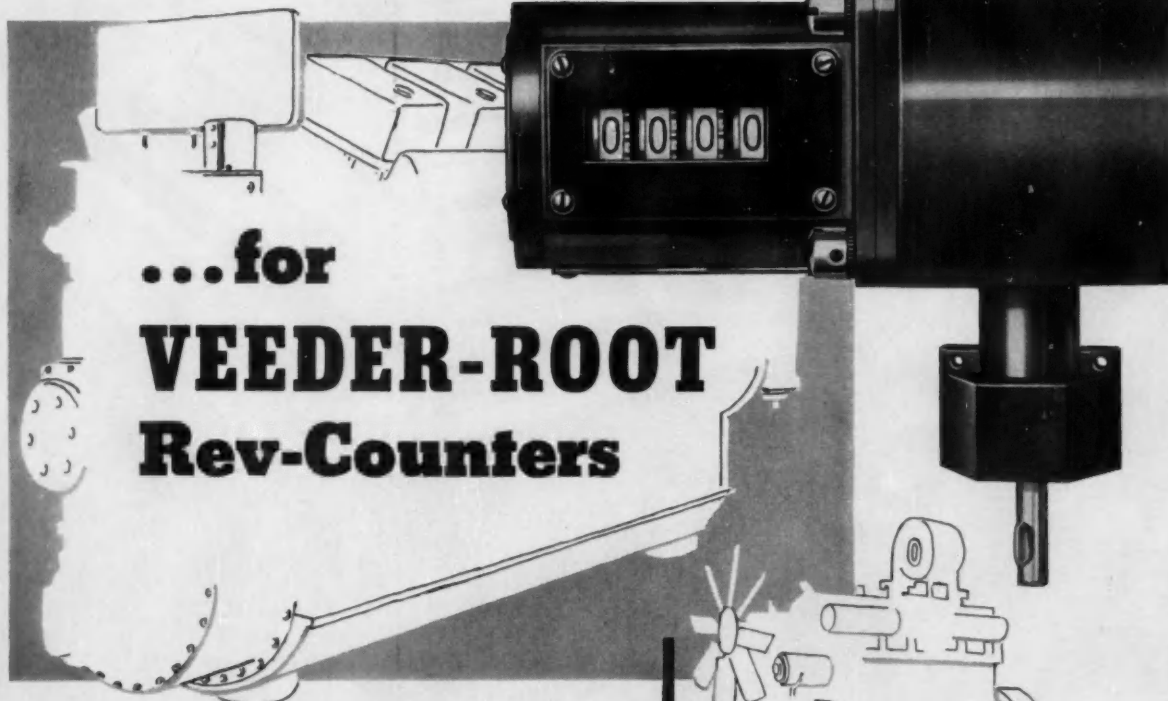
The great formability of N-A-X HIGH-STRENGTH steels makes this design easy to produce. Rounded edges add strength, safety.



In less than 20 seconds, one worker can set up a Hamlintainer, or fold it flat for easy stacking when not in use. This important benefit continues to win new friends for Hamlintainers with manufacturers.

NEW

Tachometer Take-Off



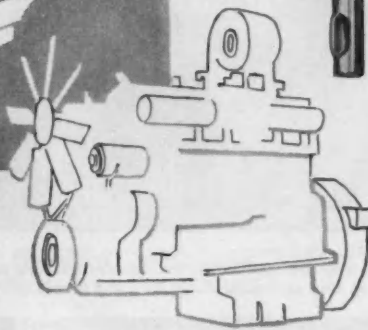
...for

VEEDER-ROOT Rev-Counters

With this new attachment, Veeder-Root Rev-Counters can be installed on any engine having a tachometer take-off in a position which is readily accessible for easy reading. Take-off can be furnished to suit average engine-speed.

So now you can make it easier than ever for your customers to see that your product is performing up to its guarantee . . . to see when routine maintenance is coming due, and whether servicing is needed.

You can count on Veeder-Root to figure out how to engineer these adaptable Rev-Counters into *your* products . . . not only engines, but generators, compressors, heaters, refrigerators, and what have you? Write:



Everyone...
Can Count on

VEEDER-ROOT

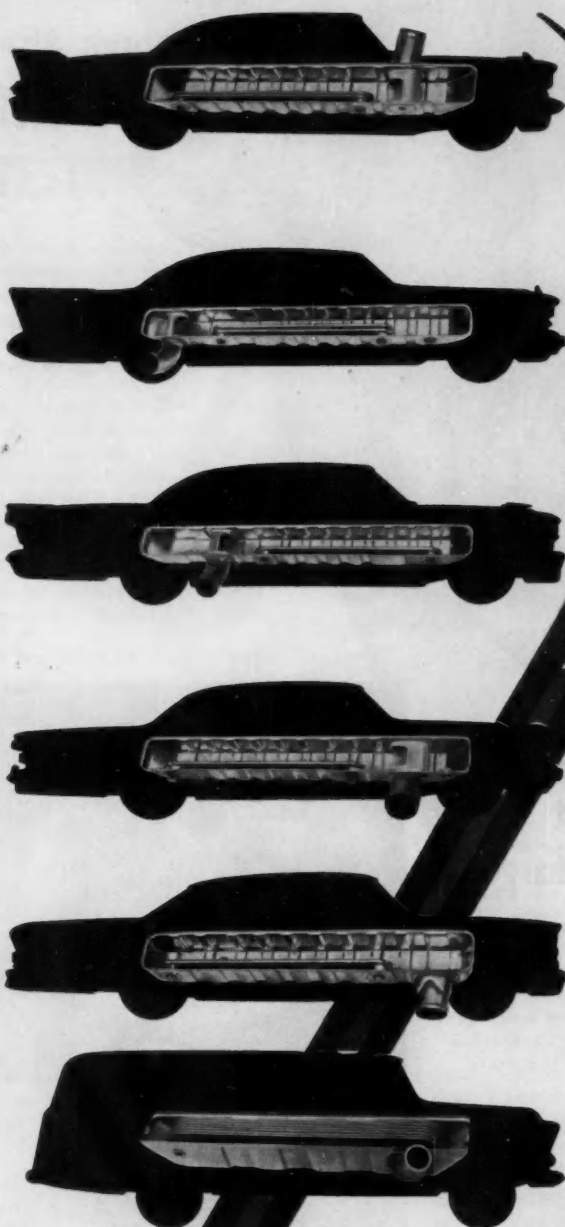
INCORPORATED

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OIL'S COOL WITH HARRISON



**Harrison
Oil Coolers ...
Specified
For All GM Cars
And Trucks Equipped
With Automatic
Transmissions!**

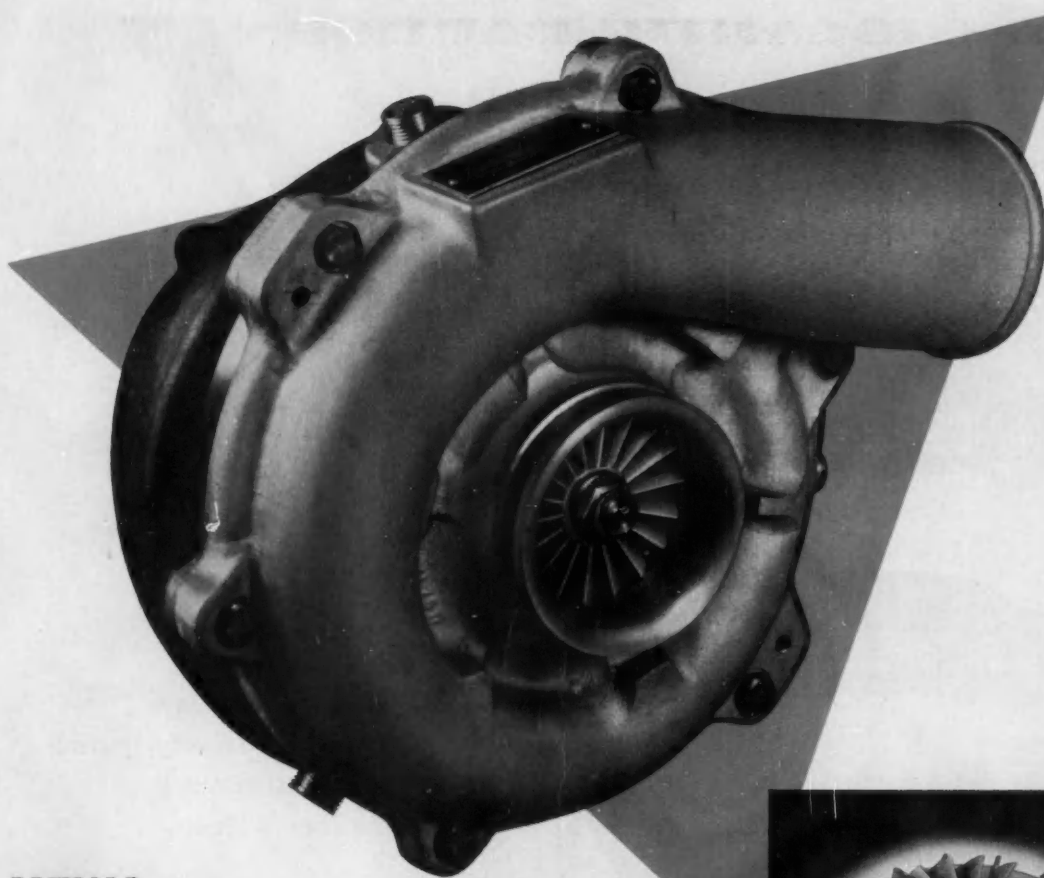
High-gear performance calls for Harrison! Again in '58, Cadillac, Buick, Oldsmobile, Pontiac, Chevrolet and GMC Truck are using Harrison coolers to eliminate heat problems with automatic transmissions. Mounted in the radiator bottom tank, these Harrison transmission oil coolers keep temperature *just right* for the most efficient operation. That's why you'll find Harrison—backed by over 47 years' experience in the heat-control business—protecting peak performance on millions of the best-known, most dependable automatic transmissions. If you have a cooling problem, look to Harrison for the answer.

TEMPERATURES MADE TO ORDER

HARRISON

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, NEW YORK





NEW! High-pressure supercharging at low rotor speeds with Thompson Turbocharger

Simple, straight rotor vanes enable the new-design Thompson Turbocharger to produce economical high-pressure blowing of diesel engines even at low rotor speeds. Wear on parts is reduced, maintenance and downtime are kept to a minimum.

In the development labs of the Jet Division, impeller vane contours were developed to make use of Thompson's two decades of experience in high efficiency movement of air and gases.

Other *new* features of Thompson Turbochargers include unique small-diameter shaft and bearing to provide lower shaft surface speeds at equal compression ratios. Bearing and shaft wear is kept to a minimum. In addition, unique Thompson design keeps exhaust heat from traveling to bearings and compressor side of the Turbocharger.

If you build supercharged diesel engines up to 300 horsepower, we can supply a Thompson Turbocharger to provide even more horsepower and fuel economy. If you install diesel engines in trucks or diesel-powered equipment, you'll increase horsepower without increasing engine size by specifying Thompson Turbochargers.

Our sales engineers will help you make the switch to Thompson Turbochargers with practically no redesign of exhaust or intake side. When may they call?



JET DIVISION
Thompson Products, Inc.

Cleveland 17, Ohio



Write today on your company letterhead for Booklet SJ-158, which contains technical data on Thompson Turbochargers for blown diesel engines up to 300 horsepower.

a moment
with management . . .

THE GREAT TESTING FALLACY

Testing is a wonderful thing. It keeps any manufacturing mistakes from ruining your reputation. It protects your customers from trouble and danger. It saves you the embarrassment and high cost of explaining, apologizing and correcting.

But testing that does these things, and **only these things**, misses a vast opportunity to save money and build profits for a manufacturer. It even hurts the customer, for it fails to give him the perfect buy of a sound product at a **minimum price**. For inevitably the price must reflect any **manufacturing waste**. Some part of the loss always gets passed along. The poverty is shared, so to speak.

What are we getting at? Simply this: End inspection is merely locking the door after the horse is stolen. Or, in plain shop language, finding out that you have already spent a lot of unnecessary money working on pieces predestined for the junk pile.

How much is wasted? It is the cost of all operations performed on the piece beyond the moment when an adequate testing procedure could have spotted the defect.

Final tests are unavoidable, essential. But never enough.

Manufacturing horse sense requires a testing setup that will spot defects at the earliest possible moment during process.

That means before the following algebra has time to get in its dirtyicks:

$$W-H (L+O)$$

or

$$\text{Waste-Hours} \times (\text{Labors} + \text{Overhead})$$

Such waste can add up to thefts of profits far greater than any ever dreamed of by the Forty Thieves of Ali Baba mentioned in our neighboring column.



Ali Baba only had 40 thieves

...and they could be cured through a light application of boiling oil. Chances are, most manufacturers have more than 40 unwitting thieves in operation at work in the plant. They won't be neatly aligned in so many stone jars, but these phantom pilferers are there nonetheless.

You'll find them "accidentally" whittling away at profits in many ways. Check your own operation...are reject rates reducable...have you need for continual rework...are you afflicted with machine downtime...how about scrap losses from defective materials, are they there, too?

True, each may only chisel a few dollars a day, but when you find them at work in scores of operations they add up. Their total may be a serious profit drain which can be plugged to achieve maximum return on your investment.

Magnaflux sells nondestructive test systems which pinpoint faulty materials and processes *before they start costing extra*. These new production tools are used to find defects at any stage of "in-process" operations. Thus they curtail wasted time, labor and materials. These industrial "burglar alarms" can protect profit margins and control consistent product quality, too!

Send for a copy of **LOWER MANUFACTURING COSTS**—our new booklet which explains where, when, why and how Magnaflux tests can help cut production costs.

moral: Oil can keep things running smoothly, but it takes Magnaflux Test Systems to keep them running profitably!

HALLMARK
OF QUALITY IN
NONDESTRUCTIVE
TEST SYSTEMS



Take Your Inspection Problems to the House of Answers . . .

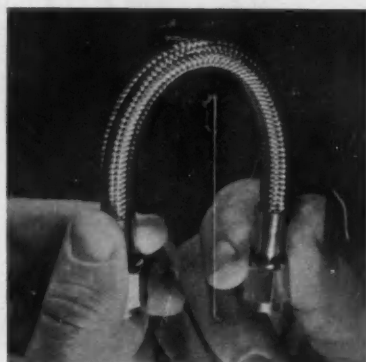
MAGNAFLUX CORPORATION

7348 W. Lawrence Avenue • Chicago 31, Illinois

New York 36 • Pittsburgh 36 • Cleveland 15 • Detroit 11 • Dallas 35 • Los Angeles 22

R/M TEFLON* hose withstands heat, pressure and vibration in air brake systems

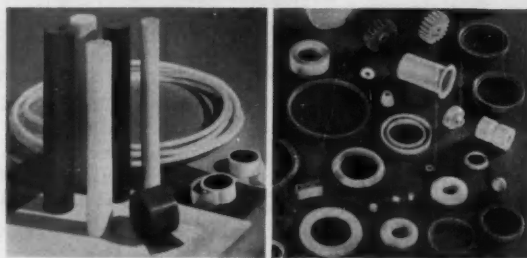
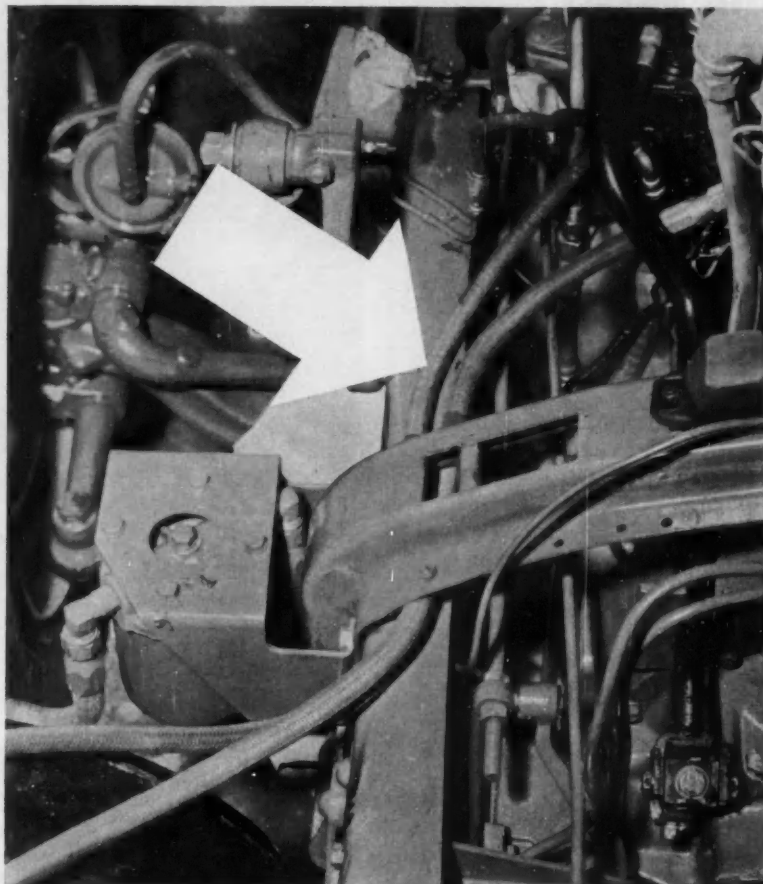
When the air brake compressor is mounted on a truck engine, the line must be guarded against breakage from vibration by a flexible coupling between the compressor and the copper tubing which carries the air to the brake system. Raybestos-Manhattan Wire-Braid Covered "Teflon" Hose is ideal in such a case . . . is specified by leading truck manufacturers because of its unique chemical, electrical and physical characteristics.



"Teflon" is chemically inert . . . immune to corrosion by the new fuels, lubricating oils, and hydraulic fluids. It is flexible and does not expand, contract or fatigue. Low coefficient of friction minimizes pressure drop in fluid systems. It functions in continuous service at temperatures from -100° to $+400^{\circ}$ F.

R/M has pioneered in exploring many new uses for "Teflon" in automotive and aircraft construction. Our research and testing laboratories and complete manufacturing facilities are yours to command in developing and producing specialized "Teflon" elements for your products.

*A DuPont trademark



Other R/M "Teflon" products of interest to your industry include rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; parts painstakingly machined to your specifications. Our mechanical grade of "Teflon"—Raylon—has many virgin "Teflon" characteristics.

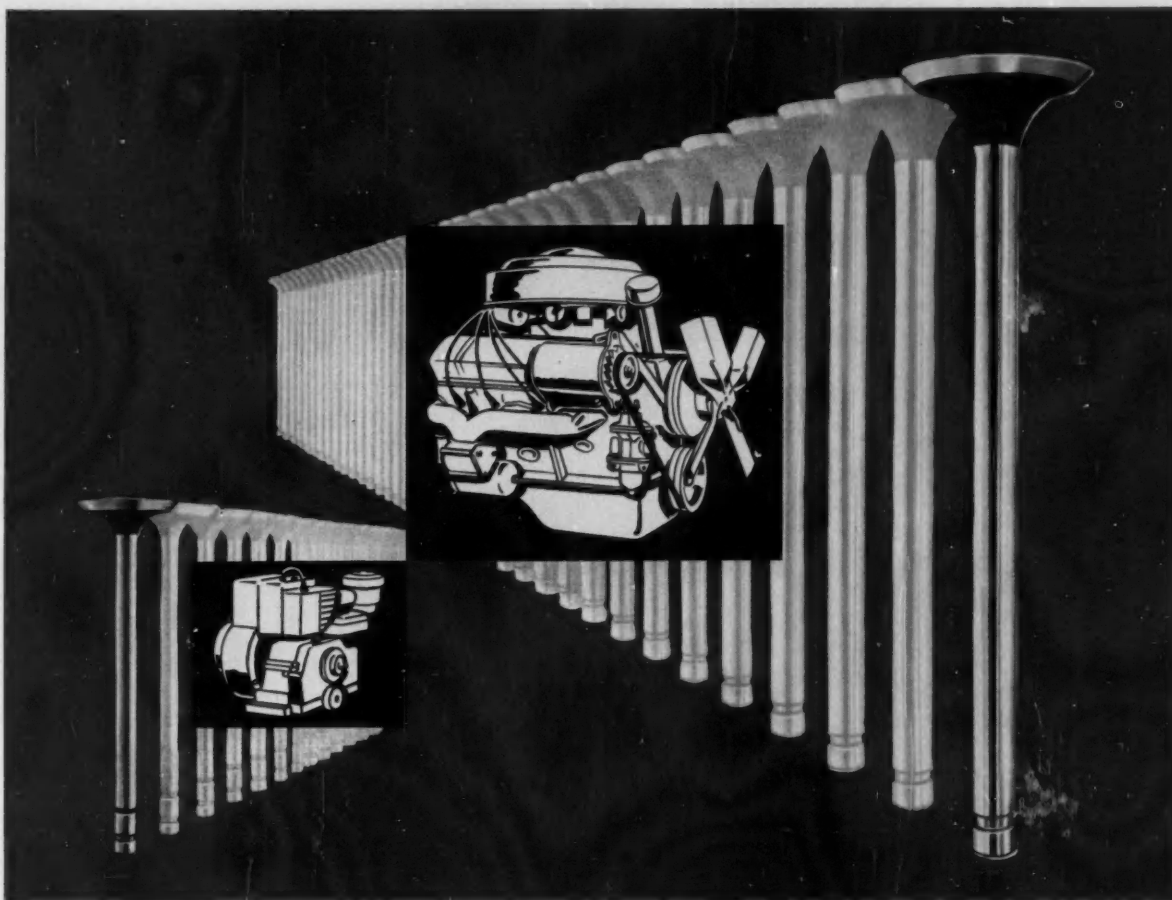


RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa. BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1 • LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3 • PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls



**any size engine...any size order...every customer
gets red-carpet service at the Valve Division**

Some customers of the Valve Division have small requirements...as few as 200 engine valves a month. Others are giants...with monthly requirements as high as 2,000,000 valves.

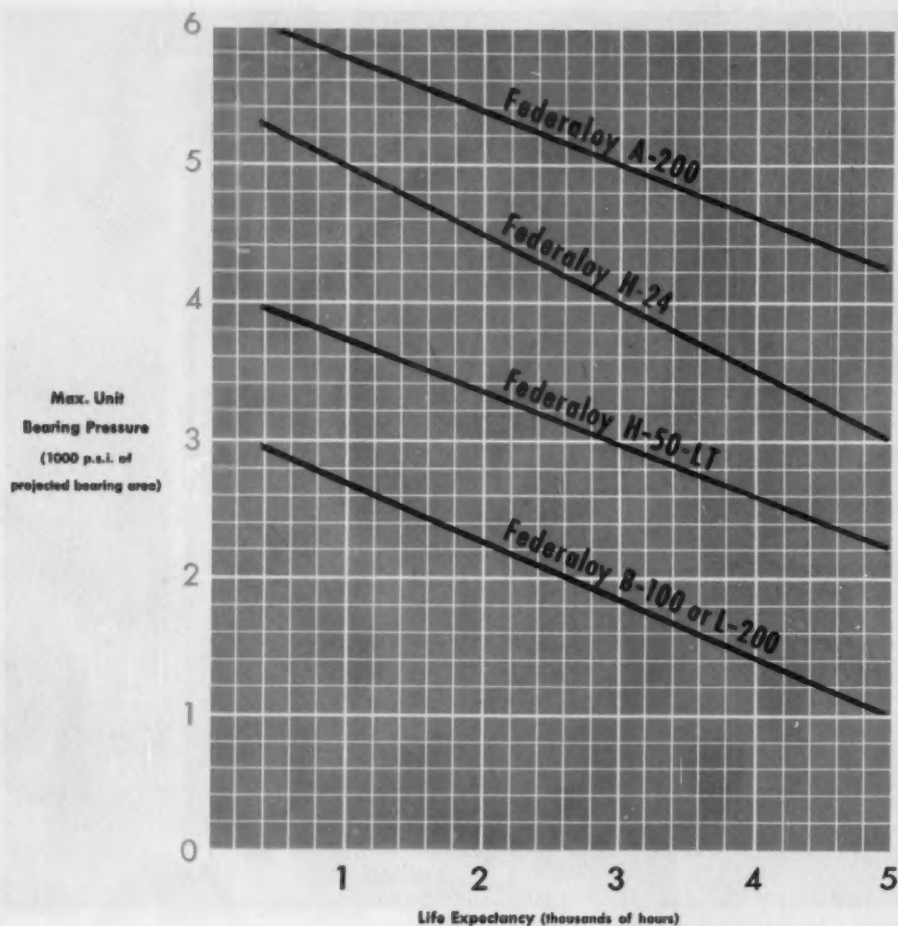
Some Thompson valve customers build small engines...as small as 1 HP for power mowers. Others build engines up to 2500 HP for industrial applications.

Yet all these customers of the Valve Division have one thing in common...the red-carpet service we strive to give each customer on engineering services, prototype parts, and the delivery of quality production valves.



Valve Division *Thompson Products, Inc.*

1455 EAST 185th STREET • CLEVELAND 10, OHIO



These alloy linings cover 95% of engine bearing requirements

With a steel back and one of these lining alloys—tin- or lead-base babbitt, medium or heavy-duty copper alloy—or extra heavy-duty aluminum alloy—95% of sleeve bearing requirements can be met with com-

plete satisfaction in performance results.

Whether your bearing is a new design or re-design of an existing application, consultation with our Engineering Department may result in tooling advantages.

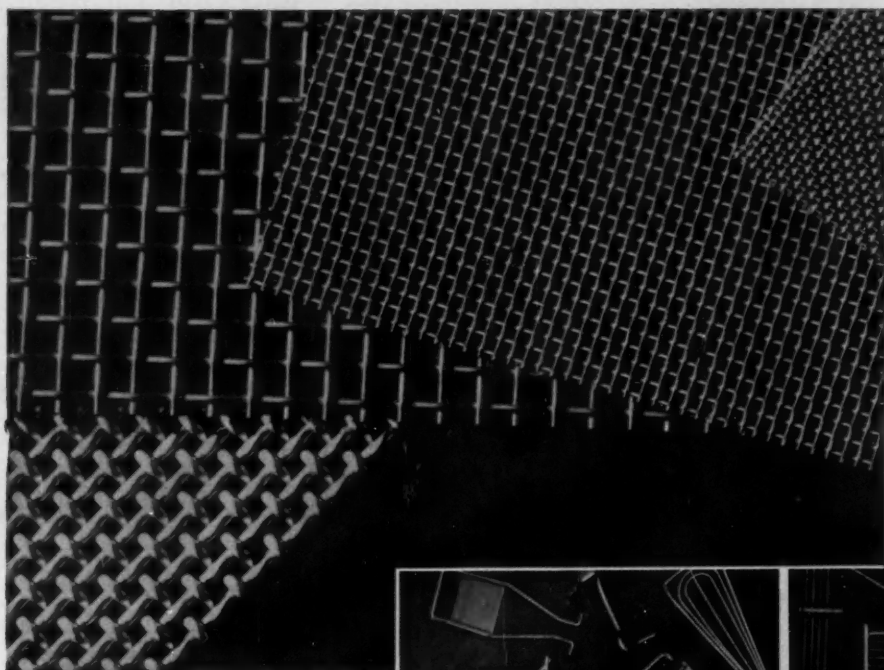


A FREE copy of
"Automotive Sleeve Type Half Bearing"
design guide will be sent on request.

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11035 SHOEMAKER, DETROIT 13, MICHIGAN

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ALLEGHENY STAINLESS BARS AND WIRE

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grades and finishes you want

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ALLEGHENY STAINLESS WIRE

Illustrated 20 page booklet, which fully describes analyses, physical properties, corrosion resistance, principal uses and applications of stainless wire.



ALLEGHENY STAINLESS BARS

Illustrated 28 page booklet, which fully covers alloy selection, fabrication, annealing, heat treating, corrosion resistance and weight of stainless bars.

ADDRESS DEPT. SA-1

Whatever your particular application may be, the variety and ready availability of Allegheny Stainless Bars and Wire offer many advantages when the requirement is resistance to corrosion, heat, wear or great stress.

Bars are produced in a complete range of analyses, in the form of rounds, octagons, hexagons, squares, flats and special shapes and sections. They can be furnished in hot rolled, cold drawn, ground and rough turned finishes, heat treated to offer a wide range of properties.

Cold drawn wire of almost all standard

grades of A-I Stainless Steel, tempered to provide many correlations of hardness and tensile strength, is obtainable in a wide selection of diameters.

In addition, our Technical Staff is at your service, ready to assist in solving problems of selection and fabrication, and to help you cut shop costs in machining, welding and finishing operations. Let us handle your stainless bar or wire requirements.

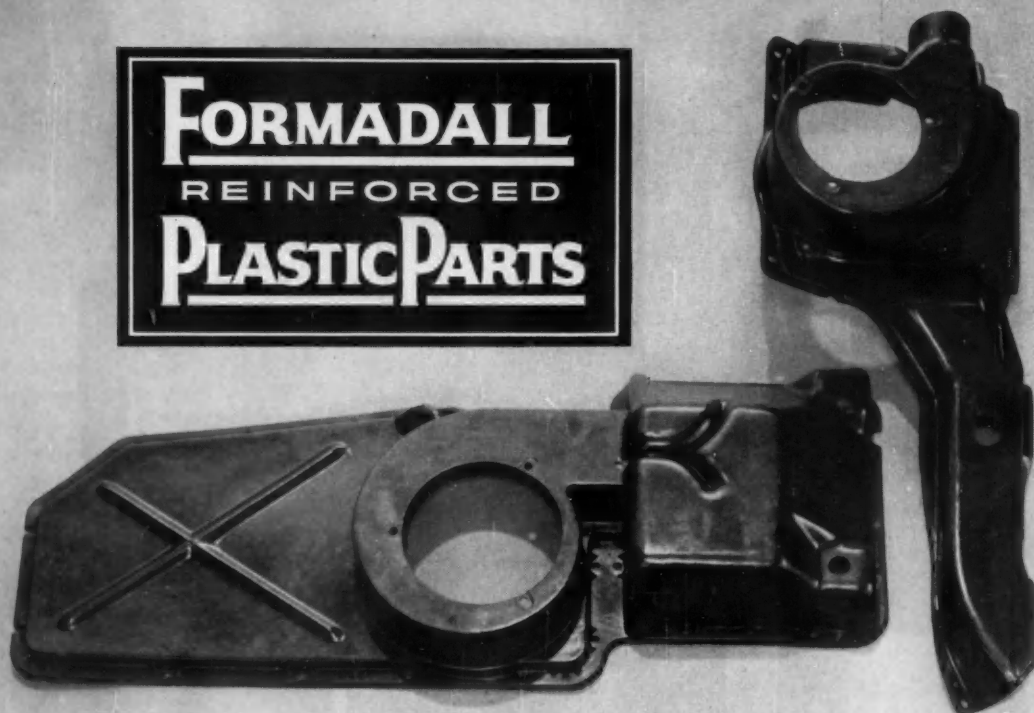
*Allegheny Ludlum Steel Corporation,
Oliver Building, Pittsburgh 22, Pa.*

Make it BETTER and LONGER LASTING with

ALLEGHENY STAINLESS

Warehouse stocks carried by all Ryerson steel plants





Heater housing and duct system developed for major automotive manufacturer* • Left, engine side; Right, passenger side

2 Large Plastic Moldings Replace 15 Major Stampings and Countless Minor Parts

A new basic material shaped to your specifications to eliminate problems of metal fabrication

The original design for the heater-defroster unit shown above was a spot-welded steel assembly which required 15 major stampings and dozens of minor parts. The problems in sealing and in assembly of the original design were obvious, and labor costs were excessive.

Through *cooperative research* with Woodall engineers, utilizing Woodall's unique prototype tech-

**Name on request.*

nique for production tests, two large Formadall moldings were developed which (1) increased thermal efficiency; (2) eliminated metallic echoes; (3) eliminated corrosion; (4) cut sealing and assembly problems; (5) reduced material and labor costs substantially.

Pioneering successful *new materials* and *new engineering* applications such as this, has been a Woodall habit for over 38 years. Why not put this extensive product development and engineering experience to work for you . . . today?

WOODALL INDUSTRIES INC.

7565 E. McNichols Road, Detroit 34, Michigan

PLANTS: DETROIT AND MONROE, MICH. • SKOKIE, ILL. • FRANKLIN, OHIO • LAUREL, MISS. • SANTA CLARA AND EL MONTE, CALIF.

Is Your Engine "Horsepower-Limited" by Tappet Face Stress?



Flat-Face Self-Aligning Tappets and Hydraulic Valve Lifters

The high cam lifts and heavy valve spring loads involved in developing higher horsepowers place increased stress on cams and tappets. Spherical face tappets make only limited-area contact with the cam, which frequently results in damaging wear or pitting. Flat-face tappets lower the unit stress, but their use has been limited by misalignment and deflection, which cause edge-riding. The Eaton self-aligning flat-face tappet permits full contact between cam and tappet to be maintained under all operating conditions.

Improve your engine by taking advantage of this new Eaton engineering development which has broken through the stress barrier. Call our engineers for a consultation.

EATON

—SAGINAW DIVISION—
MANUFACTURING COMPANY
9771 FRENCH ROAD • DETROIT 13, MICHIGAN

*A famous name in rubber and steel —
now a colorful new name in aluminum!*

FIRESTONE

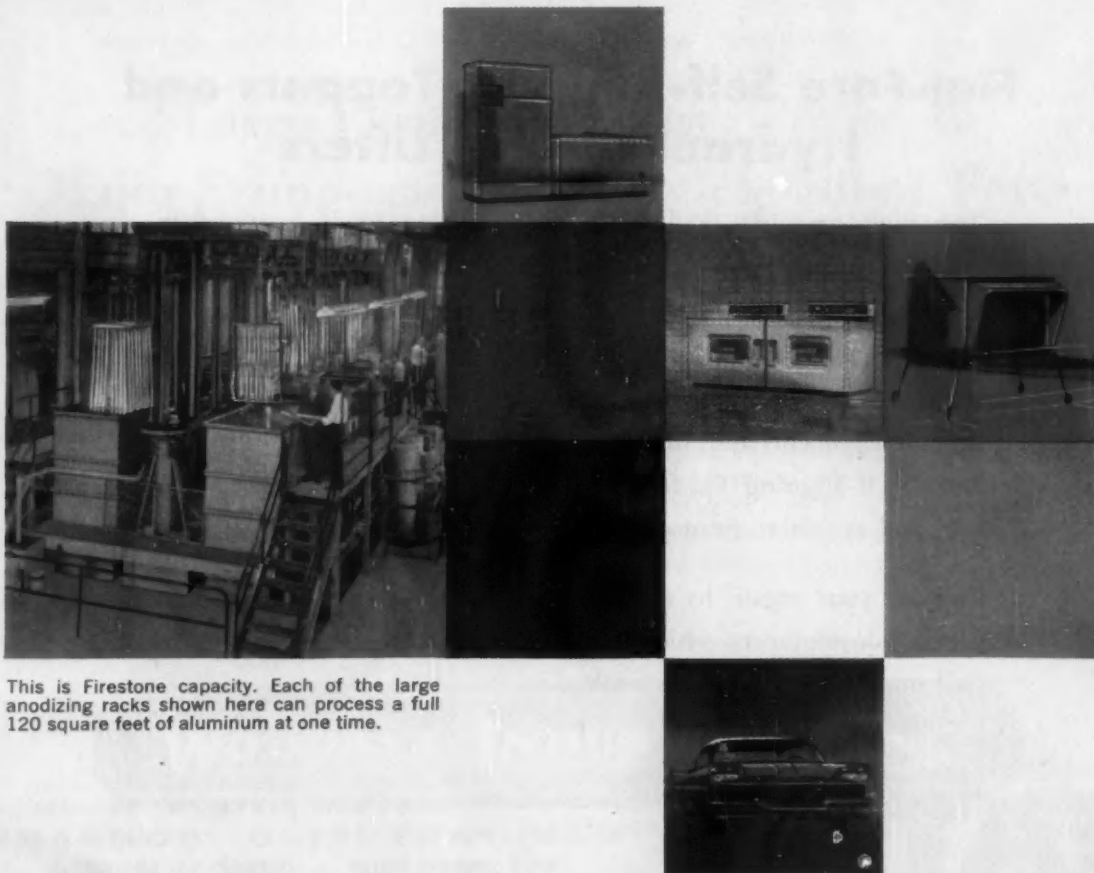
Announces Fabrication Facilities for

fashionized aluminum

color-anodized parts and trim for automotive products and home appliances

Already producing! The industry's newest, most completely automated fabricating and anodizing facility! Firestone, long a leader in supplying steel parts and trim, now offers color-bright Fashionized aluminum. Aluminum shaped, textured and color-anodized for automobile and appliance brightwork. Aluminum tailored and tinted to the most exacting specifications. Aluminum mass-produced in sizes up to seven feet long. Aluminum delivered at new competitive schedules and costs that let you make the widest use of color trim. Firestone invites your inquiries—invites you to see its fashionizing facility, one of the largest in the world.

FIRESTONE STEEL PRODUCTS COMPANY, AKRON 1, OHIO



This is Firestone capacity. Each of the large anodizing racks shown here can process a full 120 square feet of aluminum at one time.



New Kenworth 803-B rear dump truck
with Fuller 4-speed Transmission hauls
64-ton payloads.

KENWORTH'S *new mountain movers* feature **FULLER** *Transmissions*

Probably the largest rear-dump semi being built today, Kenworth's 42' 2½" rock and ore mover is equipped with a Fuller heavy duty 4-speed Transmission.

The 228,000 lb. gvw Kenworth 803-B is designed to haul top payloads profitably over varied terrain. It is powered by a single 12-cylinder diesel engine, offered in either the 400 or 600 hp range. In the 400 hp version, illustrated, a Fuller 4-speed

4-MS-1440 Transmission with CO-11,500 Twin Disc Torque Converter delivers power efficiently and effectively from the powerful Cummins NHV series engine. These heavy-duty Fuller Transmissions provide the right gear ratios to apply the power profitably.

More than 100 different transmission models are available for rubber-tired equipment from 100 to 600 hp, 330 to 1550 cubic inch engines. Check

with your truck manufacturer or write Fuller for the right transmission for your job.



FULLER MANUFACTURING CO. Transmission Division • Kalamazoo, Mich.
Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville,
Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch,
Oakland 8, Cal. and Southwest Dist. Office, Tulsa 3, Okla.



Cooling for electronic reliability...by AiResearch

SPECIFICATIONS

COOLING CAPACITY	Full 1.5 kw at 50,000 ft. ambient pressure altitude and inlet conditions as follows:
	TEMPERATURE: 10°C.
	PRESSURE: 1.7 psia
AMBIENT AIR	FLOW: 3.6 lb/min
	TEMPERATURE: 85°C.
	PRESSURE: 20 psia
CONTAINER GAS	FLOW: 9.8 lb/min

The AiResearch unit shown above solves another critical electronic cooling problem in the following manner:

The larger fan, at top left of unit, draws cooling ambient air through the heat exchanger. Simultaneously, the smaller fan, at bottom center of unit, circulates dense, non-toxic sulfur hexafluoride (SF₆) through the heat exchanger and over the electronic equipment. The cooled gas maintains the sealed electronic equipment at the desired temperature.

The 20 by 24 inch honeycomb mounting base for the cooling components is designed by AiResearch to form an integral part of the pressurized electronic equipment container.

This cooling package, incorporating standard, proved components, was developed by AiResearch in minimum time. It and other air or liquid-cooled units for similar purposes are based on almost 20 years of experience in the development of cooling systems for aircraft, missile and nuclear applications.

Send us details of your problems or contact the nearest Airsupply or Aero Engineering office for further information.



THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

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Better Things for Better Living
through Chemistry

AUTOMOTIVE ENGINEERING

LATEST PROPERTY AND APPLICATION DATA ON

TEFLON®

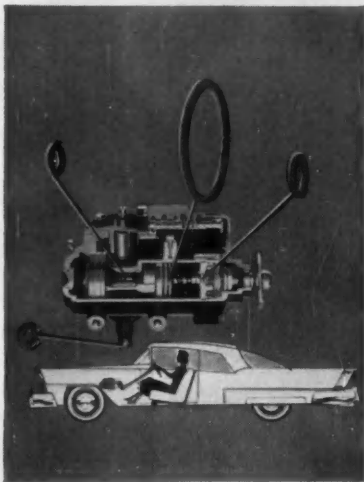
tetrafluoroethylene
resins

NEWS

Less break-away effort, smoother steering, with parts made of TEFLON 1

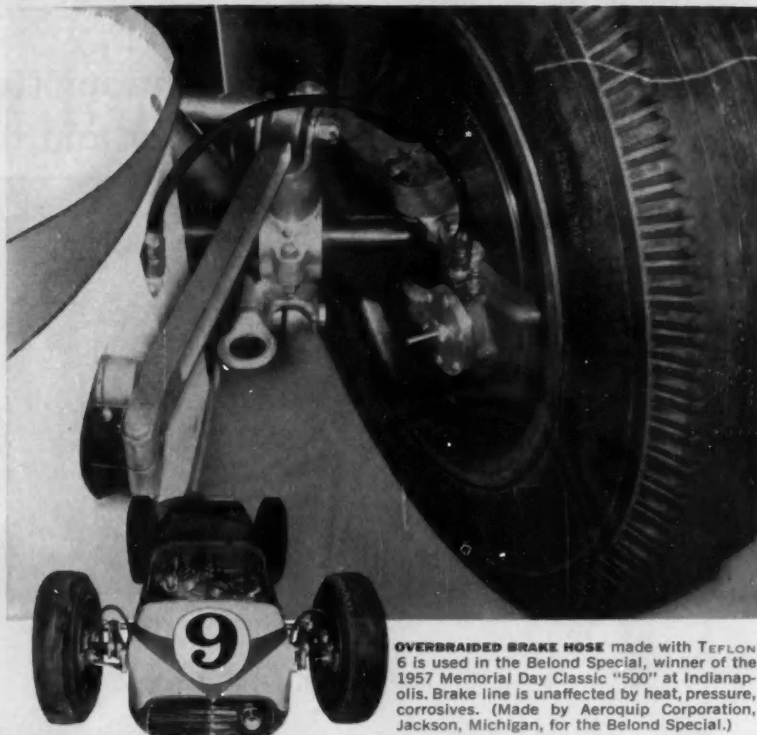
The power-steering unit shown below makes parking almost twice as easy — allows more relaxed driving. Featured in this automotive advance are the seals, piston ring, and lock-nut seal ring made of TEFLON 1, which have substantially reduced break-away effort. Even under high pressure they allow the shaft to turn freely, thus solving a binding problem caused by other materials.

TEFLON tetrafluoroethylene resins have the lowest coefficient of friction of any solid, with a measured kinetic and static coefficient of 0.04. They are suitable for use from -450°F. to $+500^{\circ}\text{F.}$, remain relatively flexible, and maintain good impact strength over this range.



Hose lines of TEFLON® end failures caused by chemical action... high temperatures

tetrafluoroethylene resins



OVERBRAIDED BRAKE HOSE made with TEFLON 6 is used in the Belond Special, winner of the 1957 Memorial Day Classic "500" at Indianapolis. Brake line is unaffected by heat, pressure, corrosives. (Made by Aeroquip Corporation, Jackson, Michigan, for the Belond Special.)

Reliability of performance and the ability to stand up under terrific punishment were the reasons for choosing overbraided brake lines made with TEFLON 6. The designer of the winning car in the Indianapolis racing classic selected these lines because they withstand all varieties of automotive chemicals and operate reliably even at a temperature of 500°F. Because of its very low volumetric expansion, the TEFLON resin

used in the lines gives a firm pedal to the brake system that previously had been impossible to achieve. Hose lines of TEFLON 6 easily withstand the vibration and flexing of a grueling track run.

Du Pont TEFLON tetrafluoroethylene resins may help make your product a winner. Send the coupon for interesting technical facts and more end-use ideas.

Watch the Du Pont "Show of the Month," 90 minutes of the very best in live television — CBS-TV network.

TEFLON®

is a registered trademark...

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the tetrafluoroethylene resins discussed herein. This registered trademark should not be used as an adjective to describe any product, nor should it be used in whole, or in part, as a trademark for a product of another concern.

BE SURE TO VISIT THE DU PONT EXHIBIT

BOOTHS 48 & 49
AUTOMOTIVE SHOW
SHERIDAN CADILLAC HOTEL
DETROIT, MICHIGAN
JANUARY 13-17, 1958

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 371, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont TEFLON tetrafluoroethylene resins. I am interested in evaluating these materials for _____

Name _____

Company _____ Position _____

Street _____

City _____ State _____

Type of Business _____

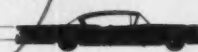
In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec

ANOTHER GREAT PRODUCT OF **AC** ENGINEERING CREATIVITY!

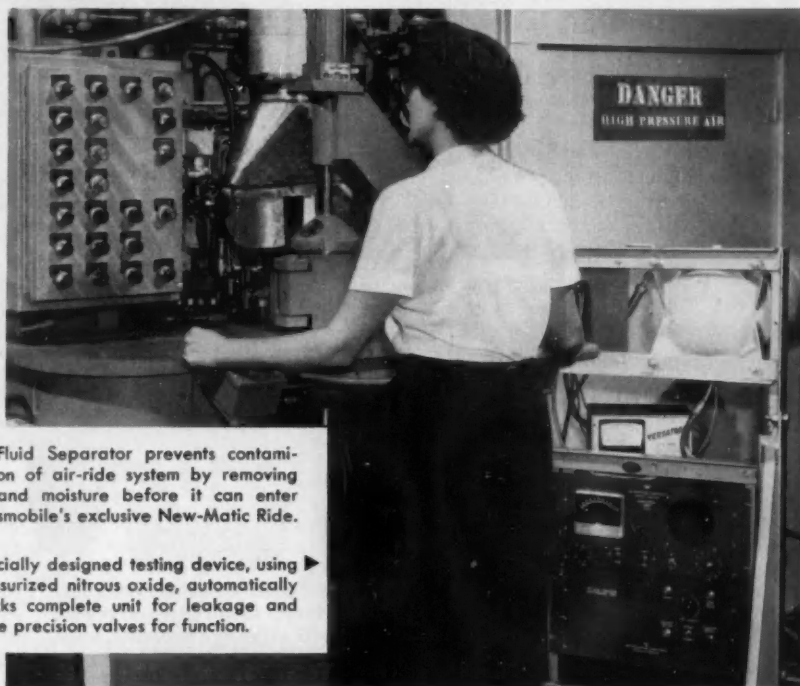


air-fluid separators

for air-ride systems



Pass several tests in automotive industry
for die casting porosity and tolerances!



◀ Air-Fluid Separator prevents contamination of air-ride system by removing oil and moisture before it can enter Oldsmobile's exclusive New-Matic Ride.

Specially designed testing device, using ▶ pressurized nitrous oxide, automatically checks complete unit for leakage and three precision valves for function.

When Oldsmobile designed its exclusive New-Matic Ride, the only true closed-system air suspension, it looked to AC engineering creativity to design and produce the all-important Air-Fluid Separator! This Separator must remove all oil and water to prevent contamination of the rubber air springs and other precision components!


The aluminum die castings and special diaphragm of the Air-Fluid Separator must withstand peak compressor pressures of 350 psi—pressure surges under the severest driving conditions—and control leakage to a maximum of four cubic inches of free air per hour!

Every Air-Fluid Separator must meet these exacting

demands before it is released to Oldsmobile by AC. A testing method unique in the automotive industry, the Versatrol is employed in these tests. Nitrous oxide, pressurized to 350 psi, is introduced into the Separator to simulate maximum operating conditions. The super-sensitive Versatrol can detect as little as one part per million of any leakage of the telltale gas.

In addition, Air-Fluid Separators are selected from production and subjected to a "burst" test of 750 psi and inspected for possible failures.

The Air-Fluid Separator is another fine example of AC's cooperation with clients to design and produce units on schedule. Consult any AC Office about your needs!

AC  THE ELECTRONICS DIVISION
OF GENERAL MOTORS



Watch Walt Disney Studios' ZORRO every week on ABC-TV

CLEVELAND

**Universal Joints,
Propeller Shafts and
Power Take-Off Joints**

...In Step With
The Modern Trend

New, more powerful engines, lower silhouette designs and smaller clearances of today's motor vehicles demand a new type of propeller shaft. It takes a plenty rugged assembly of much higher capacity, capable of working in a much smaller radius, to meet today's exacting requirements.



Having anticipated this trend to super power and super sleekness, "Cleveland" is ready with many new series of propeller shafts. These have greatly *increased* strength and *decreased* swing diameter and also incorporate the many advantages of the celebrated 32 tooth conventional spline shaft pioneered by "Cleveland".

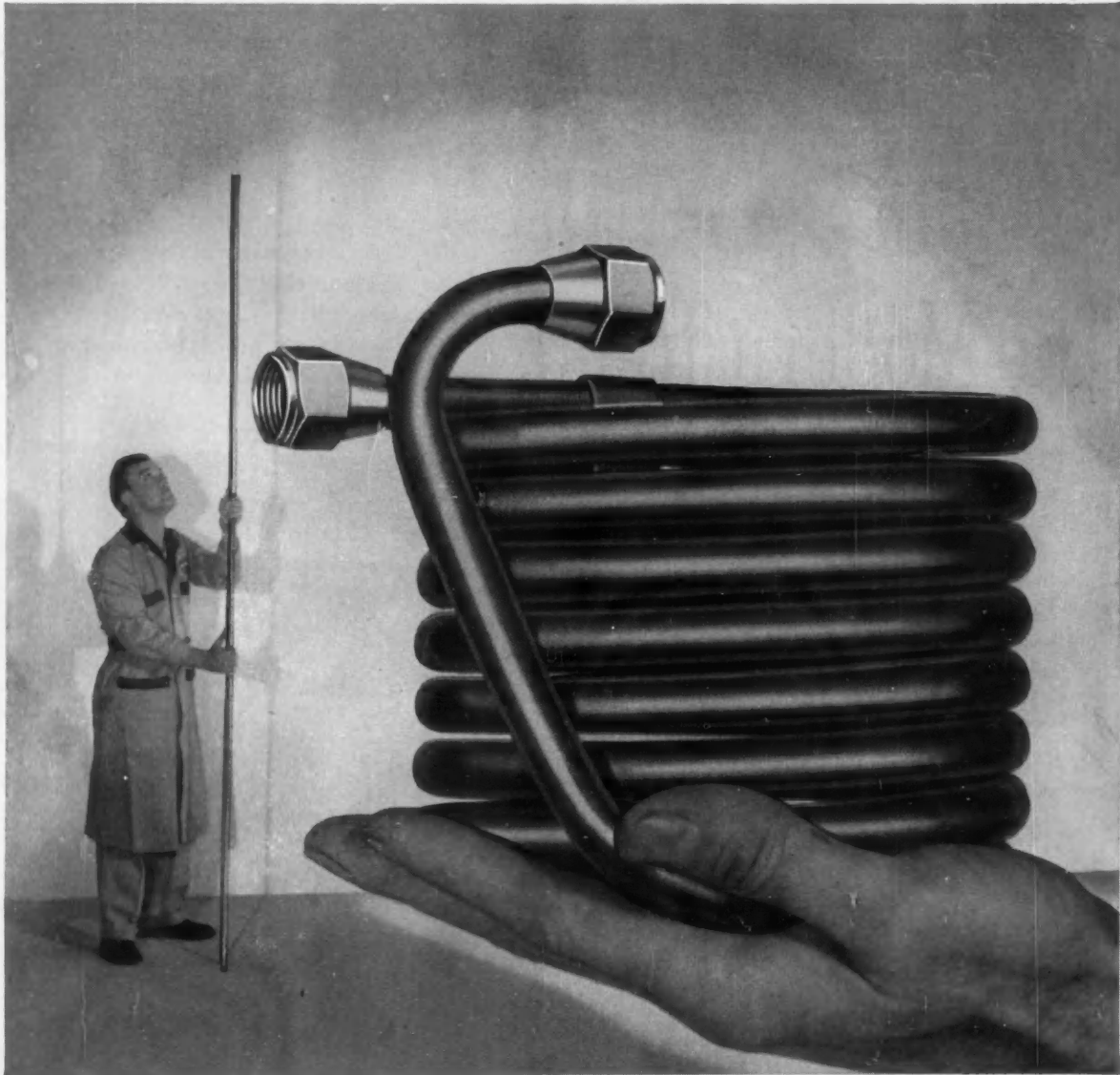


Look to "Cleveland" for propeller shaft and universal joint requirements. We'll welcome the opportunity to work with you.

**Since 1912
Cleveland Steel Products Corporation
Automotive Division**

**16025 Brookpark Road
Cleveland 11, Ohio**

Over 11 feet of ductile Bundyweld



Oil cooler for power-steering unit stands only $4\frac{3}{4}$ " high, yet contains over 11 feet of $\frac{1}{2}$ " x .035 Bundyweld Tubing. The inside diameter of the coil measures just 4.88". This I.D. dimension is held to $\pm\frac{1}{16}$ " tolerance. Ends are double-flared with fittings attached.

WHY BUNDYWELD IS BETTER TUBING



Bundyweld starts as a single strip of copper-coated steel. Then it's . . .



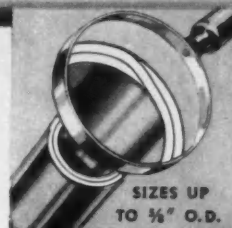
continuously rolled twice around laterally into a tube of uniform thickness, and



passed through a furnace. Copper coating fuses with steel. Result . . .



Bundyweld, double-walled and brazed through 360° of wall contact.



NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

SIZES UP TO $\frac{3}{8}$ " O.D.

go into oil cooler just 4³/₄" high

**Vital cooling coil for power-steering pump is precision-made
with all fittings attached by Bundy's efficient fabrication facilities**

This was the problem: cool the oil for a heavy-duty, hydraulic-power-steering pump; do it in limited space.

Working together, Eaton Manufacturing Company and Bundy® engineers found the answer: surround the hydraulic reservoir with a 4³/₄"-high cooling coil of Bundyweld® Tubing. Result: as hydraulic fluid is pumped through over 11 feet of tubing, its temperature drops 25° to 35°F.

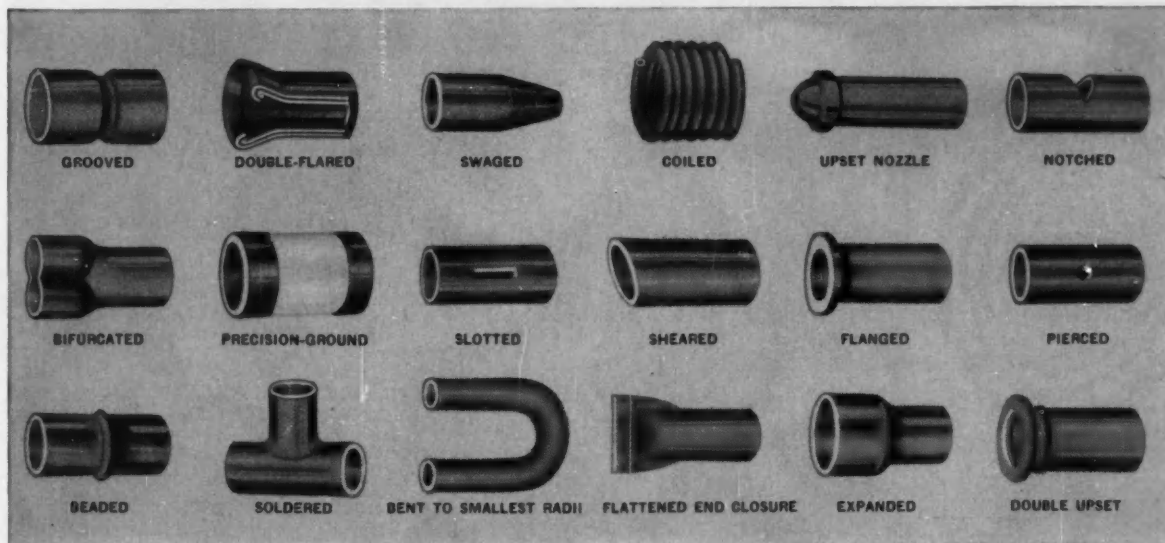
Bundy's skilled operators fabricate the oil cooler—assemble the fittings, double-flare the tubing ends, and coil the tubing. Tough fabrication jobs like this one look easy with highly versatile Bundyweld Tubing.

Made by the exclusive process shown below, left, Bundyweld has high tensile strength, bursting strength, and resistance to vibration fatigue . . . is smooth, ductile and easy to fabricate. Bundyweld is the safety standard of the automotive industry . . . is used on 95% of today's cars, in an average of 20 applications each.

If you need tubing for mechanical or fluid-transmission applications on cars, trucks or farm equipment, Bundy offers all this: free, expert engineering service; high-quality tubing in coils up to 2,000 feet . . . or fabricated to your specifications. You'll find it pays to contact Bundy first. Call, write or wire us today.

BUNDY TUBING COMPANY, DETROIT 14, MICHIGAN

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY



Shown above are but a few of the fabrication operations which are possible with Bundyweld Steel Tubing. Many of these, and others not shown, were developed through solving a specific

problem brought to us by our customers. Bundy invites you to take advantage of this design service at any stage in the development of your product.

THERE'S NO REAL SUBSTITUTE FOR

BUNDYWELD® TUBING

Bundy Tubing Distributors and Representatives: **Massachusetts:** Austin-Hastings Co., Inc., 226 Binney Street, Cambridge 42 • **Pennsylvania:** Rutan & Co., 1 Bala Ave., Bala-Cynwyd • **Midwest:** Lapham-Hickey Steel Corp., 3333 W. 47th Place, Chicago 32, Ill. • **South:** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg., Chattanooga 2, Tenn. • **Southwest:** Vinson Steel & Aluminum Co., 4606 Singleton Blvd., Dallas, Texas • **Northwest:** Eagle Metals Co., 4755 First Avenue, South, Seattle 4, Wash. • **Far West:** Pacific Metals Co., Ltd., 2187 S. Garfield, Los Angeles 22, Calif. • **Pacific Metals Co., Ltd.,** 1900 Third Street, San Francisco 7, Calif.

Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.



Typical Silastic applications by leading auto manufacturers include transmission oil seals that provide longer lasting, more efficient sealing against hot oil; and sparkplug covers that keep moisture out and withstand heat to produce better engine performance.

SILASTIC

SILICONE RUBBER

molded parts seal oil in, moisture out

Get latest data on Silastic
Mail coupon today

Dow Corning Corporation, Dept. 911
Midland, Michigan
Please send me latest data on Silastic

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COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

*T.M. REG. U.S. PAT. OFF.

Typical Properties of Silastic for Molded Parts

- Temperature Range, °F -130 to 500
- Tensile strength, psi 600 to 900
- Elongation, % 150 to 300
- Compression set, %, @ 300 F 15 to 40
- Hardness range, durometer 20 to 90
- Dielectric strength, volts/mil 400 to 500
- Oil resistance Dependent on type of oil

If you consider ALL the properties of a silicone rubber, you'll specify SILASTIC.

first in silicones

DOW CORNING
SILICONES

DOW CORNING CORPORATION • MIDLAND, MICHIGAN



Safety
Comfort
Economy



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Calibrated
Ride Control
with Any Load

MONROE

The Greatest name in Ride Control



**MONRO-MATIC SHOCK
ABSORBERS** — Standard
on more makes of cars
than any other brand.



MONROE AIR-O-STEER
Power steering for air-
equipped trucks, buses.
Installed in 2 hours.



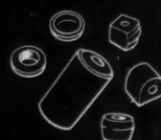
**DIRECT ACTION POWER
STEERING** — The only
truly direct-action Power
Steering units available.



MONROE SWAY BARS —
Specified as standard
equipment on 15 makes
of passenger cars.



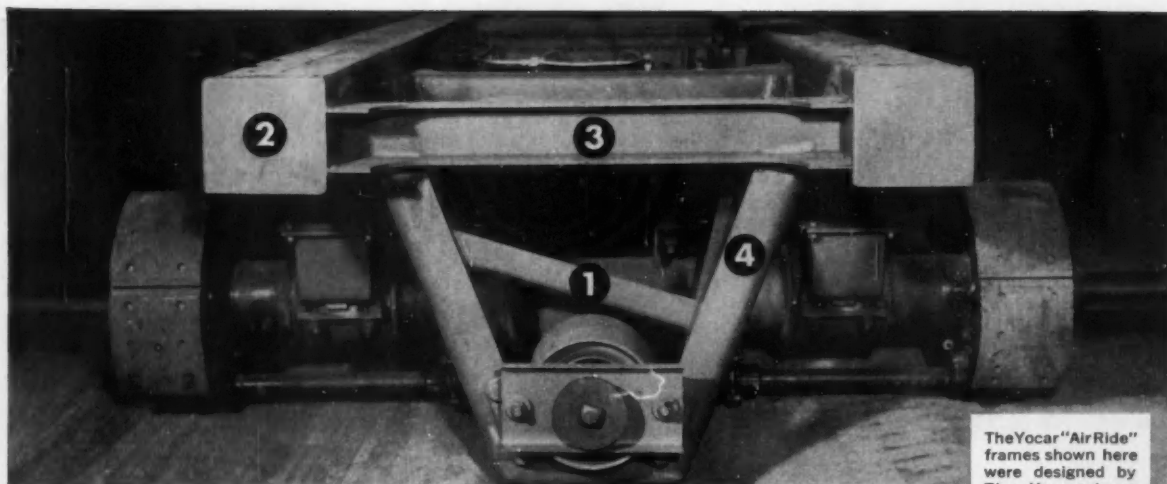
E-Z RIDE SEATS — Stand-
ard on more tractors
than all other seats of
this type combined.



**MOLDED RUBBER PRO-
DUCTS** — Precision-built
for all automotive and
industrial applications.

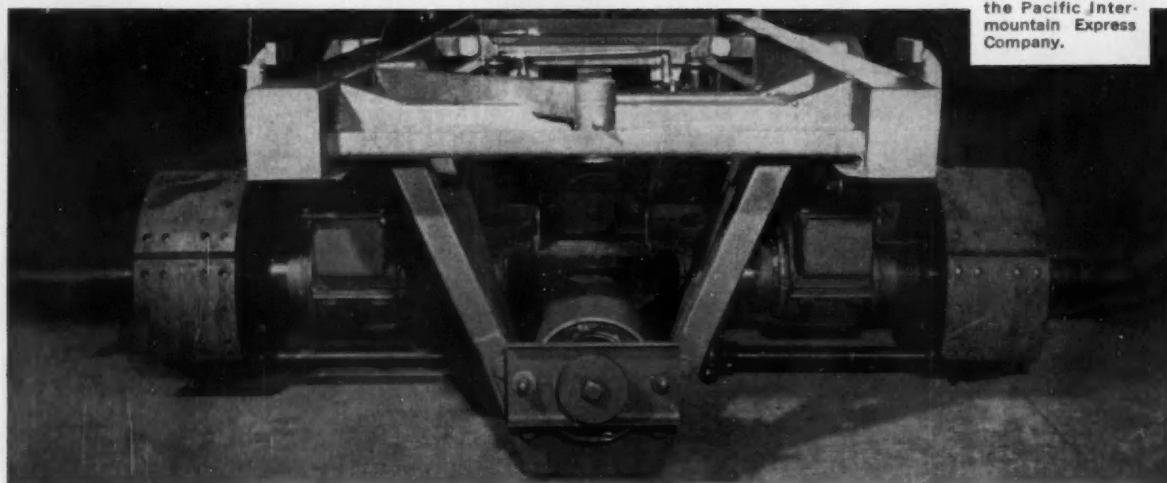
MONROE AUTO EQUIPMENT COMPANY

Monroe, Michigan — World's Largest Maker of Ride Control Products



1,187 lbs.: Standard carbon steel

The Yocar "AirRide" frames shown here were designed by The Youngstown Steel Car Co., Niles, Ohio, for installation in vehicles for the Pacific Inter-mountain Express Company.



900 lbs.: Republic "65" High Strength Steel

New trailer frame assembly weighs 24% less when made from nickel-copper-moly high strength steel

Compare the frame members numbered above. The number 1 frame has been eliminated entirely in the bottom picture. Compare, too, the thinner sections 2, 3 and 4. Each of these sections was reduced in weight when Republic High Strength Steel was used.

REASON? This nickel-copper-molybdenum steel has a high strength-to-weight ratio. The Republic "65" high strength steel used in this trailer has the following typical mechanical properties in the as-rolled condition:


Yield Point	67,000 psi
Ultimate Tensile Strength	89,000 psi
Elongation in 2 inches.....	18%

RESULT? Design engineers can take advantage of these excellent mechanical properties to incorporate thinner

and lighter sections with no sacrifice in strength and safety.

Compared to conventional carbon steels, the use of high strength alloy steels results in important weight reduction . . . often as much as 50%.

If you must save weight and want a steel with high strength-to-weight ratio, excellent mechanical properties and superior corrosion resistance, a high strength, nickel alloy steel may be the answer for you, too. Inco will be happy to help you select one that fits your need. Just write.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street  New York 5, N. Y.

INCO NICKEL

BLOOD BROTHERS SERVES INDUSTRY

WITH UNIVERSAL JOINTS AND ASSEMBLIES
FOR ALMOST ANY PRODUCT APPLICATION

SIZES AND TYPES FOR HEAVY-DUTY
AUTOMOTIVE, CONSTRUCTION AND
ROAD BUILDING MACHINES, FARM
IMPLEMENTS, TRACTORS AND INDUS-
TRIAL MACHINERY.



SAVE ENGINEERING TIME!

Here at Blood Brothers you can select from a wide, wide range of universal joints and complete drive assemblies. Torque capacities range from 350 to 500,000 inch lbs. — lengths from very close-coupled industrial joints to assemblies 120" overall.

You can be confident they are produced in a modern, centrally located plant, tooled for precision manufacturing. And you can rely on their high reputation for dependability.

When you specify Blood Brothers, you can save valuable engineering time by stating your problem to our service-minded engineers. They're cooperative, friendly and long-experienced. Just write or call.

WRITE FOR BULLETIN 557

and for your
convenience in
specifying, request
our free Blank
Form "Specification
Sheets".



BLOOD BROTHERS MACHINE DIVISION

ROCKWELL SPRING AND AXLE COMPANY

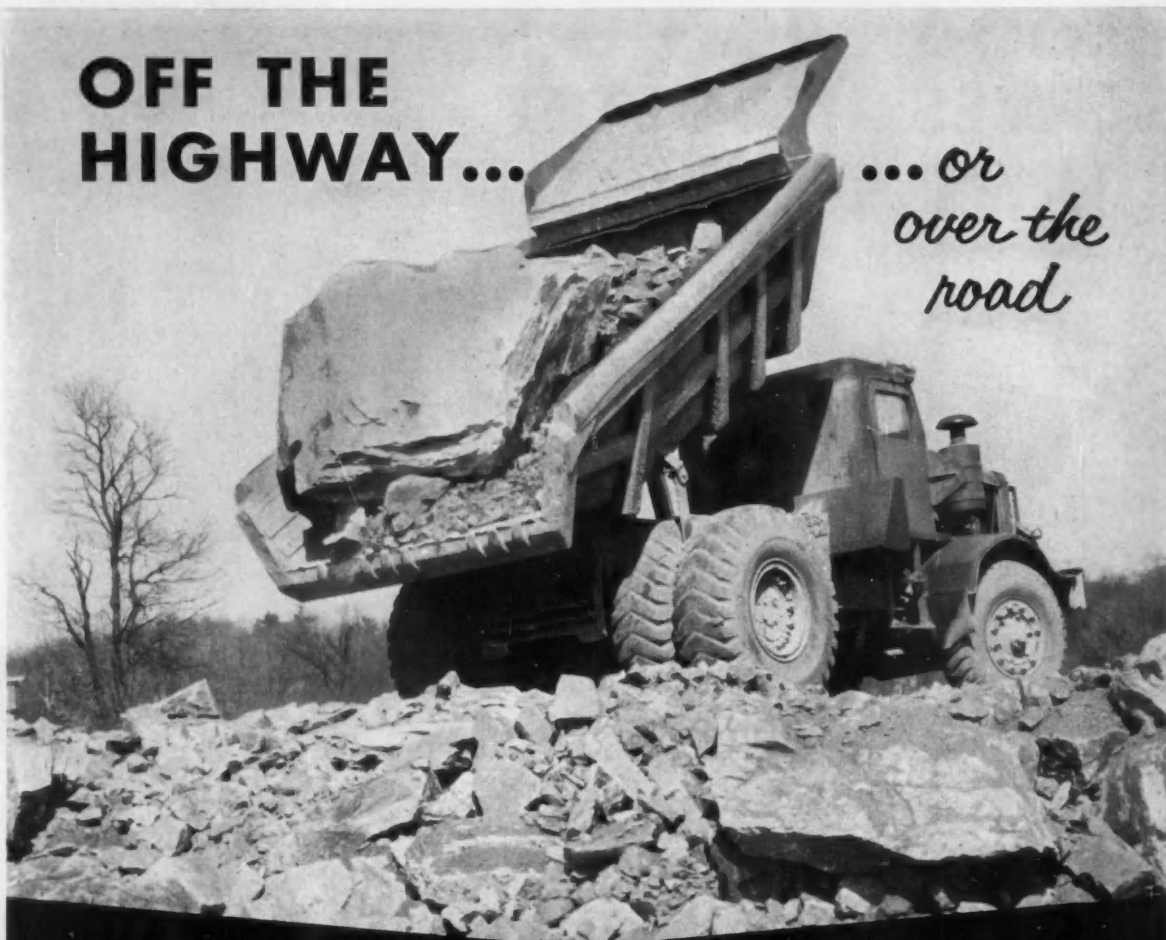
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS
AND DRIVE LINE
ASSEMBLIES

Copyright 1957, Blood Brothers Machine Div.

**OFF THE
HIGHWAY...**

*... or
over the
road*



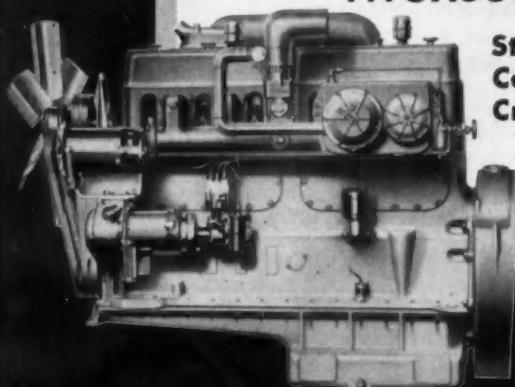
WAUKESHA ENGINES

**NORMAL and TURBOCHARGED DIESELS
... GASOLINE ... LP GAS**

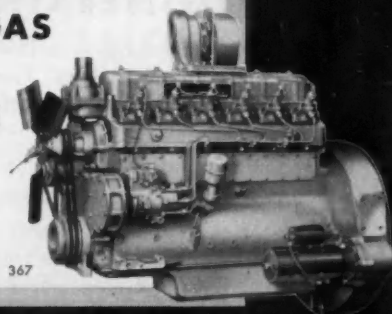
**Standard or
Counterbalanced
Crankshafts**

*Write for
descriptive
bulletins*

367



Waukesha WAKB—Equipped for Butane—6-cylinder,
6 1/4 x 6 1/2-in., 1197 cu. in., 300 max. hp. @ 1800 rpm.

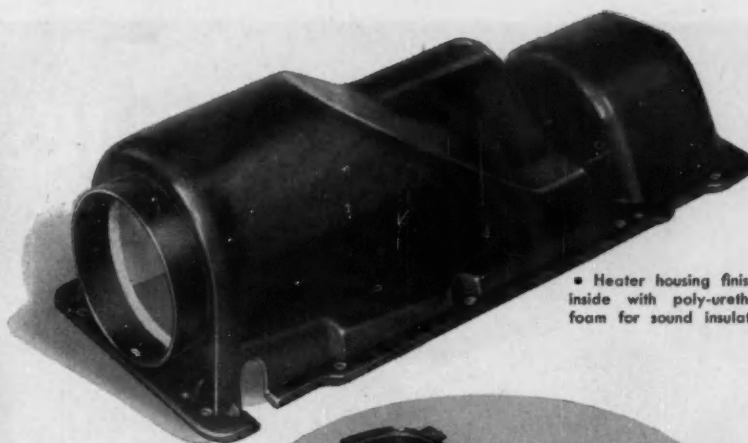


Waukesha 197-DLCS Turbocharged Diesel
(also normally aspirated)—6-cylinder,
4 x 4-in., 302 cu. in., 131 max. hp. @ 2800 rpm.

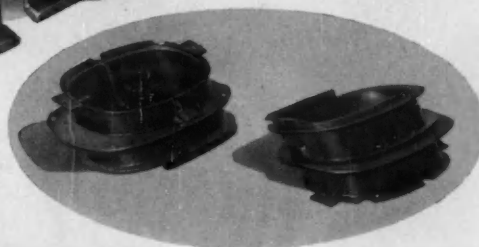
WAUKESHA MOTOR COMPANY
Waukesha, Wisconsin • New York • Tulsa • Los Angeles



• Car air conditioning ducts covered with poly-urethane foam for thermal insulation.



• Heater housing finished inside with poly-urethane foam for sound insulation.



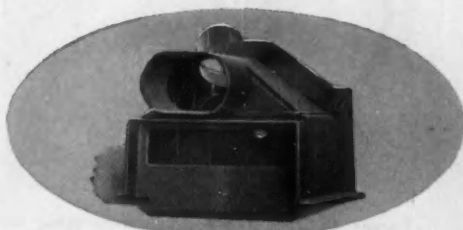
• Reinforced plastic shrouds for car side air duct outlets.

FABRICON

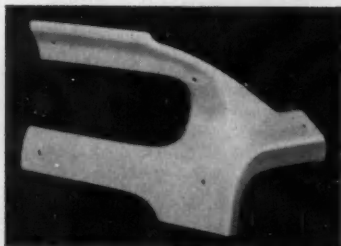
REINFORCED PLASTIC MOLDINGS



• Heater blower housing.



• Housing for air conditioning system.



• Exterior trim molding ready to be finished with a decorative simulated wood grain pattern.

Custom premix compounds plus new improved processing techniques permit economical volume production of intricate, complex parts

Intricate, complex parts are difficult to design and costly to make out of metals. That's why more and more design and production engineers are turning to Fabricon reinforced plastic moldings for the answers to their problems. For component parts like those shown here can be quickly, easily produced with relatively inexpensive tooling . . . formed at once into finished pieces that require no costly secondary operations. What's more, they are made of special custom premix compounds developed by Fabricon after years of working with all types of resins and fiber reinforcements. And they are processed by modern laboratory controlled molding techniques which assure consistent uniformity of quality plus the best possible combination of the physical properties required for each individual application.

Want detailed information on how Fabricon products, facilities and services can be of help to you? Just outline the nature of your problem for prompt engineering recommendations . . . or send print of part for firm quotation.



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A Division of The EAGLE-PICHER Company

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See the Fabricon Products Display — Booth 42 — SAE Annual Meeting — January 13-17 — Sheraton-Cadillac Hotel, Detroit

Don't buy O-rings blindly!



Prove by comparison tests that Parker O-rings seal better, last longer

Comparison tests will show you that Parker O-rings are better. You can't *see* the difference. You can't *feel* the difference. But in *use*, Parker O-rings actually do seal better and last longer!

Why? Because Parker O-rings are precision-molded of superior compounds developed by exhaustive research and experimentation. Our engineering service will help you with your particular problems — whether in gland design or compound. From Parker, you get the *right* O-ring for your *specific* application. Compare Parker O-rings and

discover the difference for yourself.

These trouble-free, leakproof seals are carefully evaluated for elongation, tensile strength, compression set ratings, resistance to oils, fuels, chemicals and temperature extremes. Exacting laboratory and service tests make sure that Parker O-rings meet applicable specifications. Whatever your requirements, Parker can supply the O-rings you need.

Ask your Parker O-ring distributor today for new O-ring Size Catalog or mail the coupon for your copy.



Parker O-Lube is especially formulated for O-ring lubrication requirements. It comes in a handy, squeeze-tube container.

PARKER RUBBER DIVISION



parker hannifin
creative leader in fluid systems

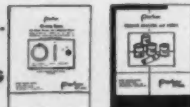
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DIVISION, Section 525-06**
Parker-Hannifin
Corporation,

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1538 South Eastern Ave., Los Angeles, Cal.

Please send:

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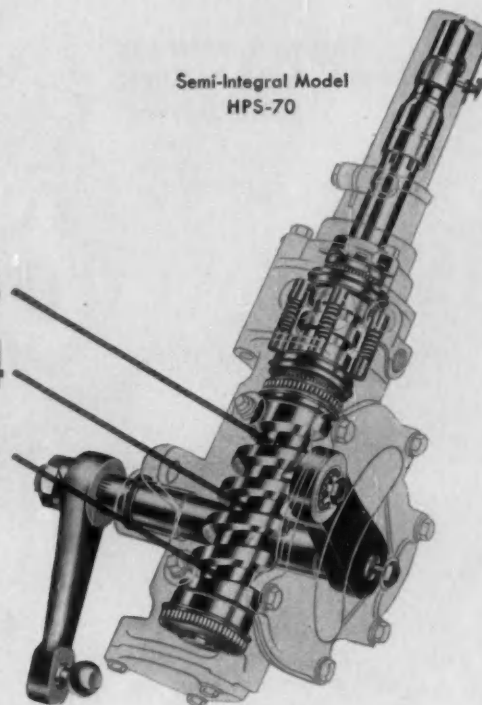
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COMPANY _____
ADDRESS _____
CITY _____ STATE _____



ONLY *Ross* GIVES
VARIABLE-RATIO
 POWER STEERING

Semi-Integral Model
 HPS-70

18
 24
 18



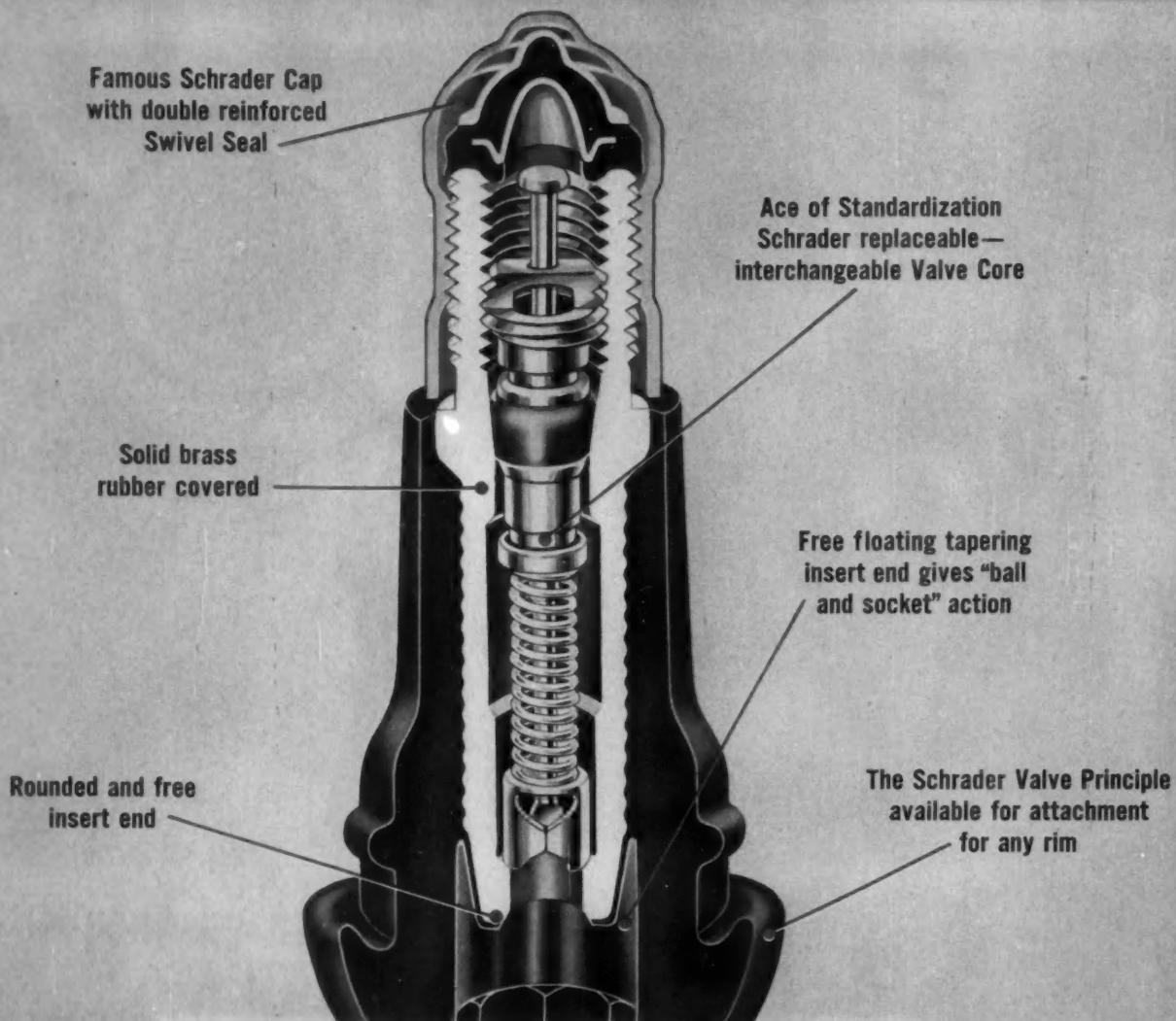
faster for cornering . . . slower for straight-ahead

- **What's the advantage** of *variable-ratio* steering? For example . . . 18:24:18?
- **Variable-ratio** provides faster steering and quicker recovery for cornering, and slower steering and greater stability for high-speed, straight-ahead driving.
- **Variable-ratio** is an exclusive feature of Ross Hydrapower power steering and Ross Cam & Lever manual steering. No other type of steering gear provides it.
- **Ross makes all three** types of hydraulic power steering—integral, semi-integral and linkage—and invites discussion of *any* steering problem, power or manual, variable or fixed ratio.

Ross

HYDRAPOWER

ROSS GEAR & TOOL COMPANY, INC. • LAFAYETTE, INDIANA
 Gemmer Division • Detroit



Famous tire valve operating principle
known as the

ACE OF STANDARDIZATION

SCHRADER TIRE VALVES

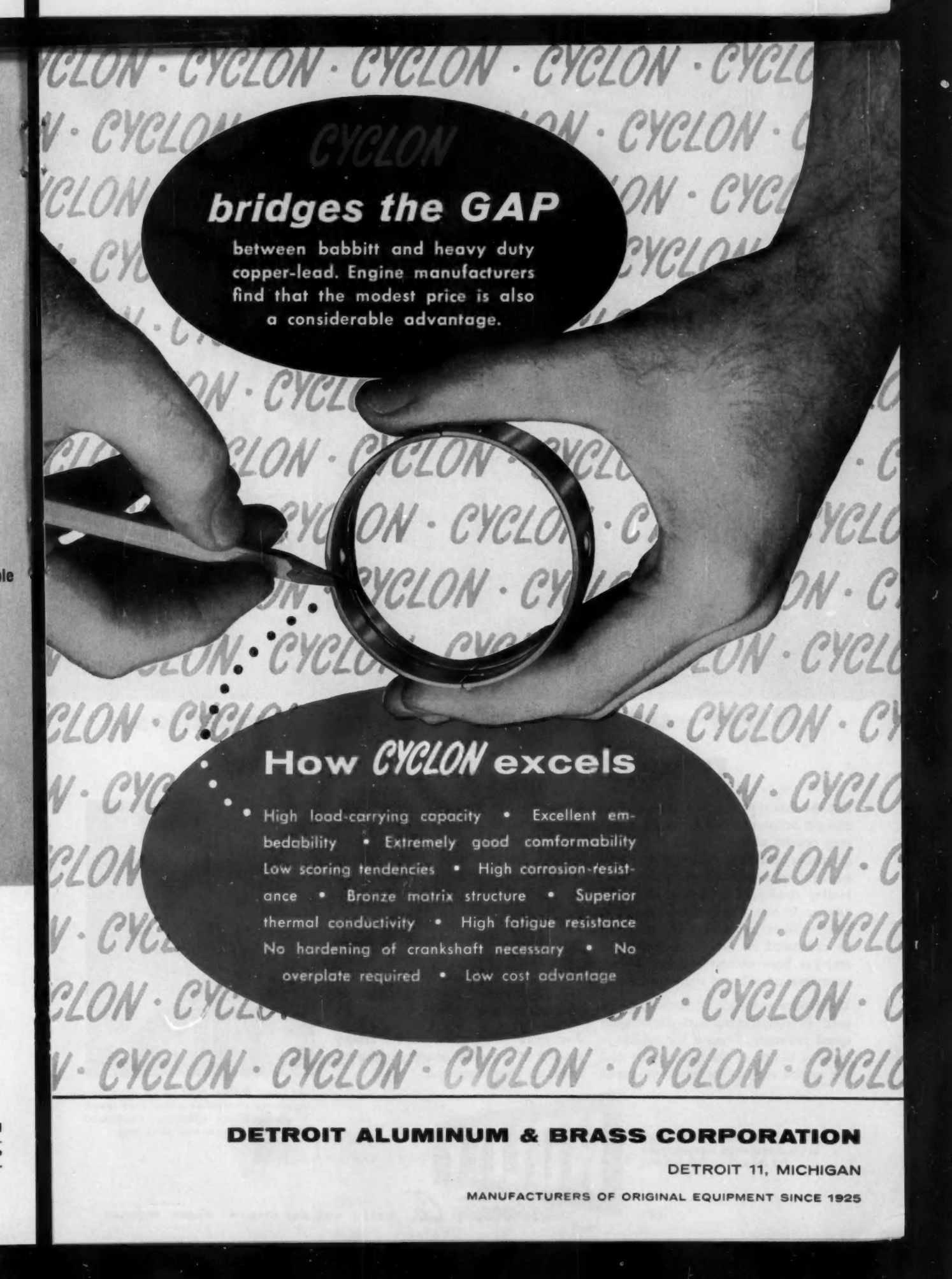
hold this distinction in all industry because of
Schrader quality, reliability, safety and performance
... since the first pneumatic-equipped vehicle

Schrader
a division of **SCOVILL**

FIRST NAME IN TIRE VALVES

FOR ORIGINAL EQUIPMENT AND REPLACEMENT

A. SCHRADER'S SON
Division of Scovill Manufacturing Co., Inc.
470 Vanderbilt Avenue
Brooklyn 38, N. Y.



bridges the GAP

between babbitt and heavy duty copper-lead. Engine manufacturers find that the modest price is also a considerable advantage.

How CYCLON excels

- High load-carrying capacity
- Excellent embedability
- Extremely good conformability
- Low scoring tendencies
- High corrosion-resistance
- Bronze matrix structure
- Superior thermal conductivity
- High fatigue resistance
- No hardening of crankshaft necessary
- No overplate required
- Low cost advantage

DETROIT ALUMINUM & BRASS CORPORATION

DETROIT 11, MICHIGAN

MANUFACTURERS OF ORIGINAL EQUIPMENT SINCE 1925



NOW—a truck governor that regulates road speed—not engine speed

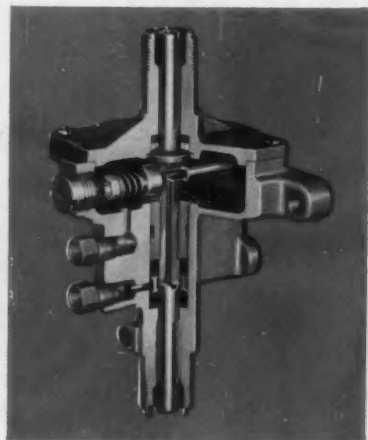
For the first time, truck fleet operators can get accurate, predetermined economy results with all trucks by having all trucks operate at road speeds which have proven most economical. The new Holley roadspeed governor is driven relative to rear wheel speed instead of relative to engine speed. It can easily be calibrated for any truck gear ratio and has been successfully tested over thousands of miles of road conditions.

The Holley roadspeed governor can be used in conjunction with the engine speed governor. Thus, if the vehicle is running in one of the lower gears and the engine reaches its governed speed

before reaching the predetermined mile per hour setting, the engine speed governor controls. In the event that road speed is reached prior to the engine rpm maximum setting, as in high gear, the roadspeed governor controls.

The roadspeed governor offers fleet operators a complete governing system designed to allow maximum horsepower under extreme load conditions and yet providing pinpoint control of road speed for maximum economy.

For more information on the Holley roadspeed governor, simply send a request on your letterhead.



The new Holley road speed governor, engineered to regulate actual road speed, is designed to eliminate mechanical trouble and prevent malfunctioning.

*For more than half-a-century
original equipment manufacturers
for the automotive industry.*

HOLLEY
Carburetor Co.

T-8

11955 E. NINE MILE ROAD • WARREN, MICHIGAN



bright idea

For enduring beauty that sells in a new car and
re-sells in a used car . . . design it, improve it and protect it
with McLOUTH STAINLESS STEEL.

specify

Mc LOUTH STAINLESS STEEL

H I G H Q U A L I T Y S H E E T A N D S T R I P

for automobiles



McLOUTH STEEL CORPORATION DETROIT, MICHIGAN
MANUFACTURERS OF STAINLESS AND CARBON STEELS

FOR UNIFORM SHELL MOLD STRUCTURE SPECIFY RCI'S FOUNDREZ 7500



FOUNDREZ 7500 is a very finely powdered thermosetting phenolic resin. You will find that it blends easily, gives uniform shell mold structure and strength in economical sand-to-resin ratios.

When you produce shell molds with FOUNDREZ 7500, you reduce curing cycles. This remarkable RCI resin performs satisfactorily at extremely high oven temperatures, lets you turn out more molds per hour.

While FOUNDREZ 7500 works well in almost all applications, it is especially recommended for tough and intricate jobs where the

patterns have a deep draw, and where the sand must flow, fill and bake extra well.

FOUNDREZ 7504 is very similar to FOUNDREZ 7500 but is faster setting and intended for use in high speed production. It generally gives a more rigid shell mold than FOUNDREZ 7500.

For large and small parts cast with any ferrous or non-ferrous material, shell molding with FOUNDREZ 7500 and 7504 is ideal... particularly for long production runs. For technical help or complete information, write to RCI Foundry Division in White Plains.



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Synthetic Resins • Chemical Colors • Industrial Adhesives • Plasticizers
Phenol • Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride
Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sulfuric Acid
REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

ROTARY ACTUATORS by **HOUDAILLE**

FOR MISSILE AND AIRFRAME APPLICATIONS
— wherever rotary motion is required

... save **WEIGHT**

... save **SPACE**

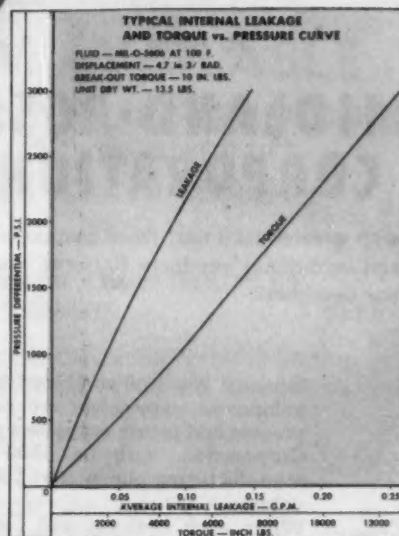
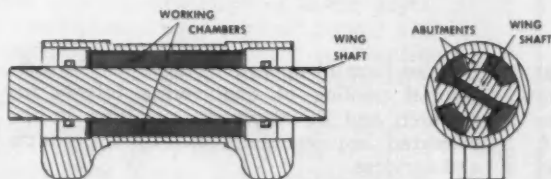
... save **DESIGN TIME**

Lightweight rotary actuators by Houdaille will fit envelopes too small for conventional linear types . . . for hinge-line mounting with direct rotary torque output, without mechanical conversion. They eliminate undesirable backlash and provide the most simplified actuating system.

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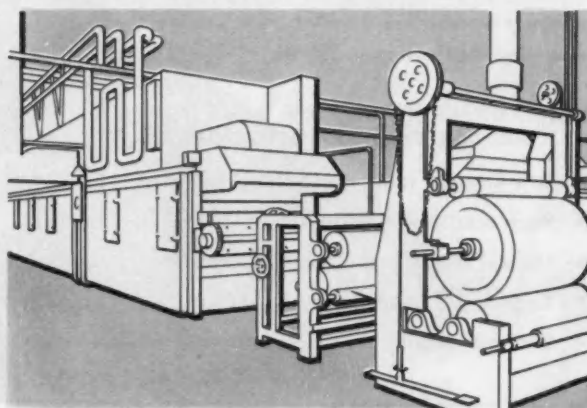
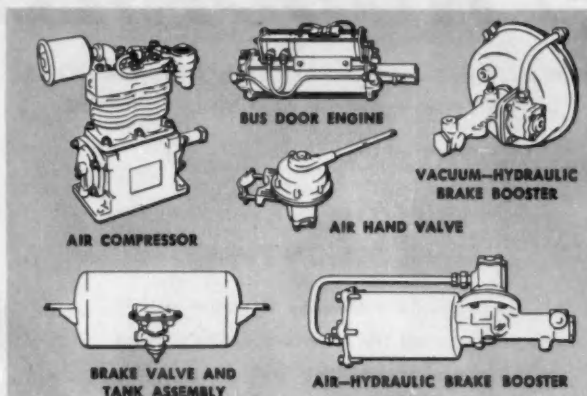
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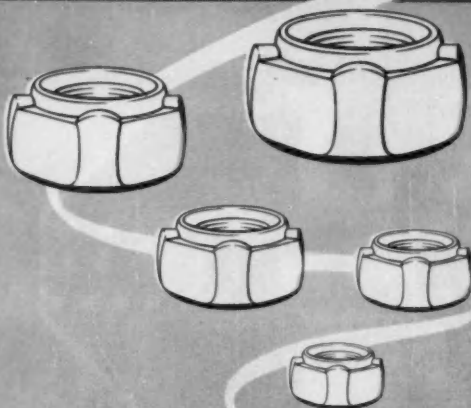
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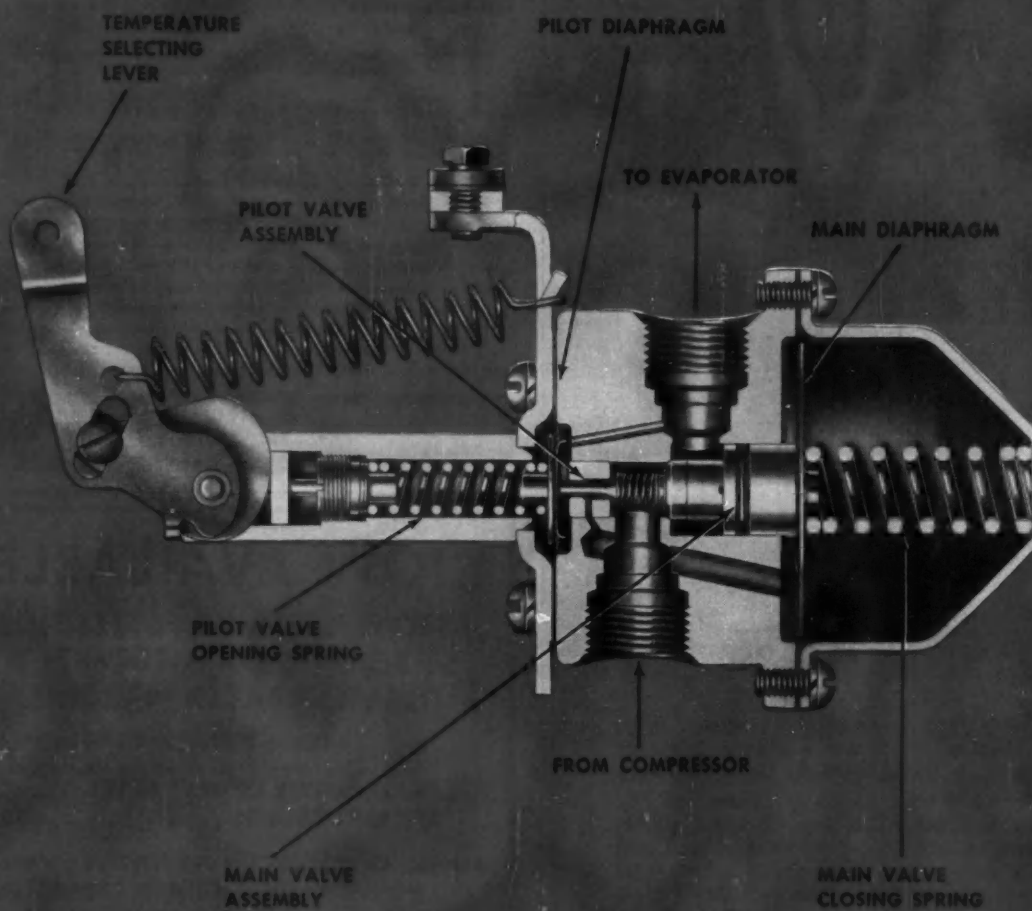
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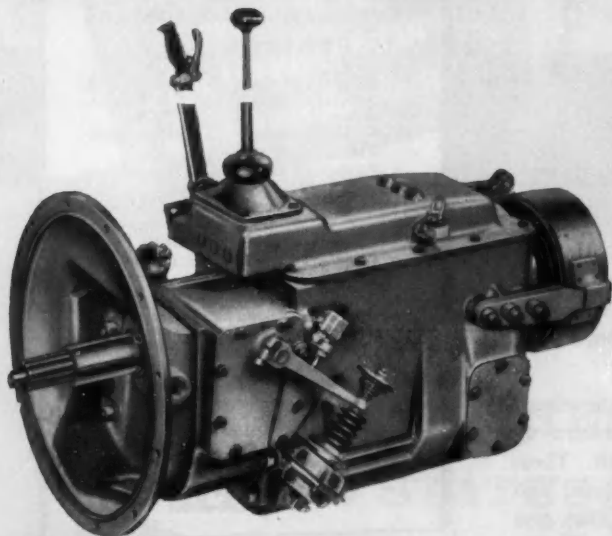
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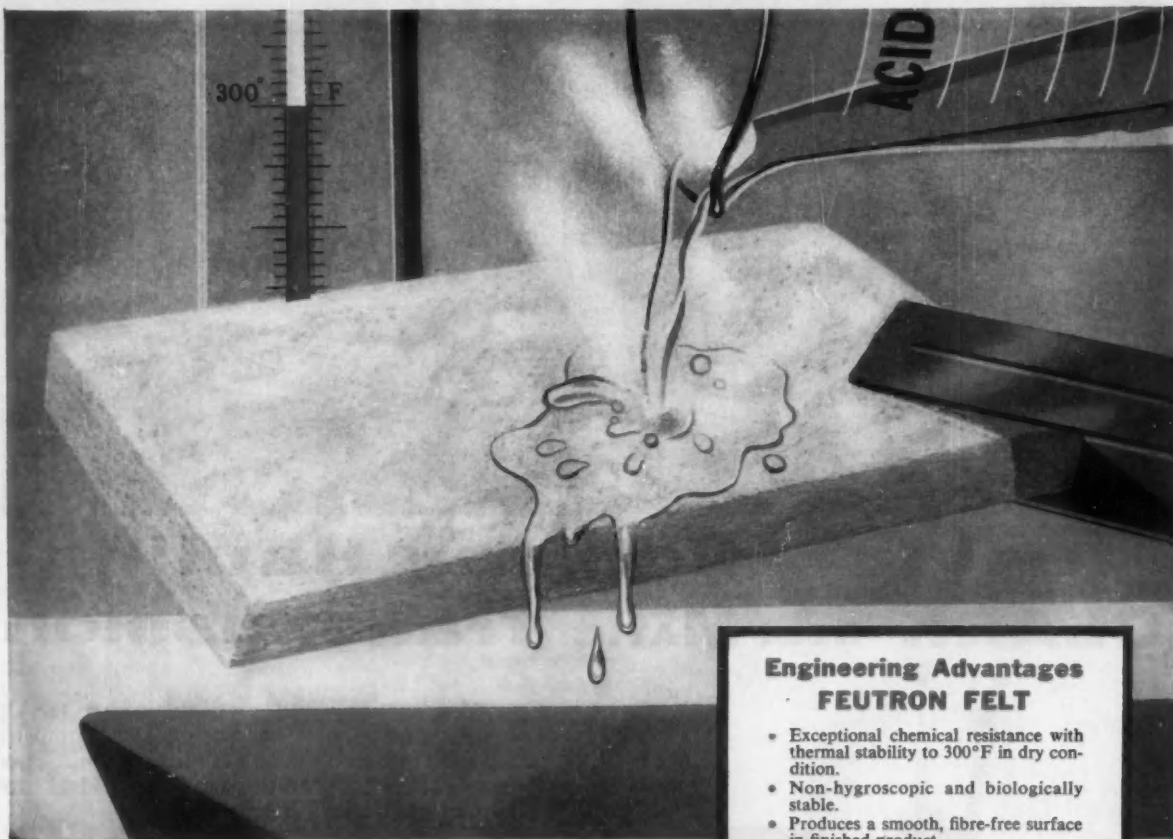
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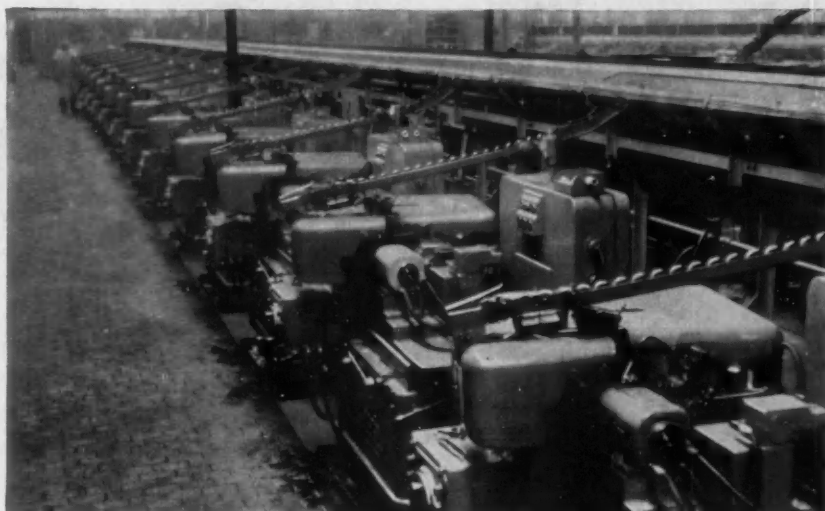
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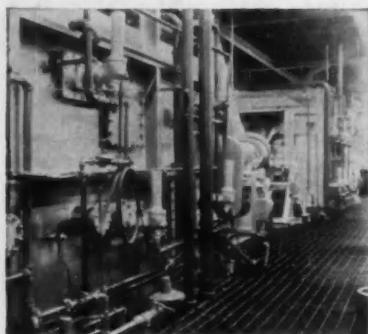
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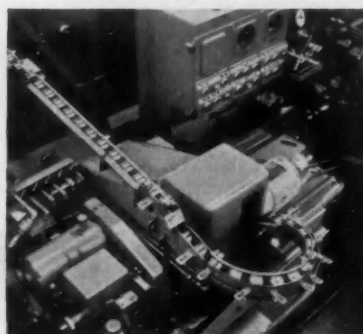
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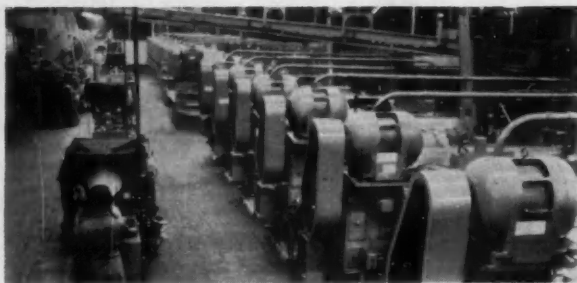
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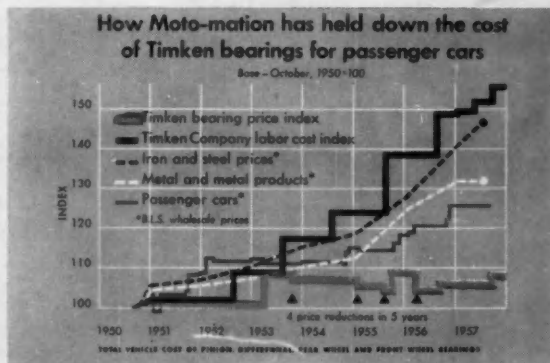
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